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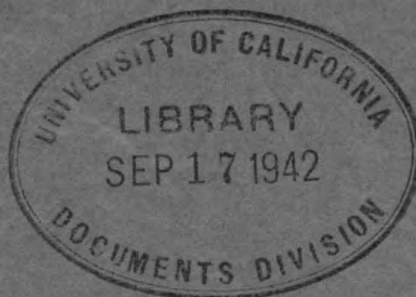
U.S. WAR DEPARTMENT

U.S. Army

TECHNICAL MANUAL

**FIELD ARTILLERY
FIRE-CONTROL INSTRUMENTS**

February 26, 1941



FIELD ARTILLERY FIRE-CONTROL INSTRUMENTS

CHANGES
No. 1

WAR DEPARTMENT,
WASHINGTON, April 22, 1942.

TM 6-220, February 26, 1941, is changed as follows:

79. Care of lenses and windows.

* * * * *

b. A special tissue paper for lens is issued for cleaning lens. No other wiping materials should be used on optical parts of instruments. In using this paper the optical surfaces may first be moistened by the breath and the surface then cleaned with the paper. Special care should be taken to keep the paper free from grit, dirt, or dust which might scratch the surface.

* * * * *

d. To remove oil or grease from lenses and windows, apply alcohol with a camel's-hair brush and rub off gently with lens paper.

* * * * *

[A. G. 062.11 (3-27-42).] (C. 1, April 22, 1942.)

81. Tools, accessories, and cleaning material.—The following is a list of authorized tools, accessories, and cleaning materials for the maintenance, adjustment, and preservation of the instruments:

Instrument	Tools and accessories	Cleaning material	Where carried
Range finder.....	1 adjusting key..	1 cleaning brush, paper, lens, tissue.	Instrument carrying case. Do. Carrying case.
Battery commander's telescope.	2 amber glass disks.	1 camel's-hair brush, paper, lens, tissue.	
Field glasses.....	-----	1 camel's-hair brush, small; paper, lens, tissue.	

[A. G. 062.11 (3-27-42).] (C 1, April 22, 1942.)

APPENDIX (Added)

COMPASS, M2

	Paragraph
General.....	1
Compass.....	2
Declinating compass.....	3
Use of declination constant.....	4
Measuring an azimuth.....	5
Measuring vertical angle (angle of site).....	6
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1. General.—The compass, M2, is for use in measuring azimuths, either *Y* or magnetic, for which purpose it employs a magnetic needle. It is also equipped with a clinometer, by means of which vertical angles in mils (angles of site) may be measured; for this purpose it employs a tubular level. It is provided with a carrying case, M19.

2. Compass (fig. 1).—The compass is housed in an aluminum case which is generally square with rounded corners. The case has a hinged cover of the same shape and metal. The major parts of the compass, their locations, and purposes are—

a. Front sight, hinged to the cover on the side opposite the cover hinge.

b. Hairline, across the center of the mirror perpendicular to the cover hinge, for sighting purposes.

c. Circular level, mounted on the angle-of-site arm and turning with it, levels the instrument for azimuth measurements.

d. Angle-of-site lever pivot supports the angle-of-site arm. The angle-of-site lever (not lettered in the figure) turns the angle-of-site arm and is operated from outside the case.

e. Tubular level, mounted on the angle-of-site arm and turning with it, used in measuring vertical angles.

f. Magnetic needle, turning on a jewel pivot and locked by closing the cover, for measuring horizontal angles.

g. Sight holder, hinged to the case on the side opposite the cover hinge, folds inside the cover when the cover is closed.

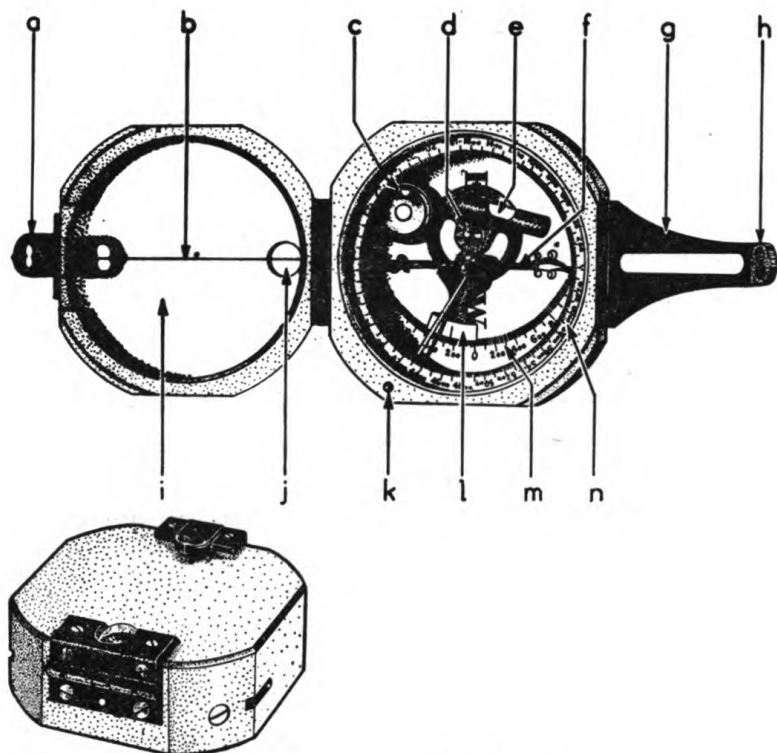
h. Rear sight, hinged to the sight holder, may be turned to form a right angle with it.

i. Mirror, mounted inside the cover, for indirect readings of levels and scales.

j. Cover window, an oval window through the cover and cover hinge, for certain sighting operations.

k. Lifting pin, in the top of the case, operated by the cover when closed, lifts and locks the magnetic needle from its pivot.

l. Angle-of-site arm turns on its pivot screw in the bottom of the case; by means of the angle-of-site index on this arm, readings are taken from the angle-of-site scale.



- a. Front sight.
- b. Hairline.
- c. Circular level.
- d. Angle-of-site lever pivot.
- e. Tubular level.
- f. Magnetic needle.
- g. Sight holder.
- h. Rear sight.

- i. Mirror.
- j. Cover window.
- k. Lifting pin.
- l. Angle-of-site arm.
- m. Angle-of-site scale.
- n. Azimuth scale.
- o. Azimuth scale index.
- p. Azimuth scale adjuster.

FIGURE 1.—Compass, M2.

m. Angle-of-site scale, etched in the bottom of the case. The scale extends from 0 (horizontal) to 1,200 mils on either side and is marked at 20-mil intervals.

n. Azimuth scale may be revolved in the case by the azimuth scale adjuster. The azimuth scale is divided into 320 equal parts, each representing 20 mils.

o. Azimuth scale index, a needle point mounted in the case, directly opposite the center of the cover hinge and immediately above the azimuth scale, for determining the exact position of the azimuth scale in the case.

p. Azimuth scale adjuster, mounted in the side of the case, for setting off the declination constant, or for setting the azimuth scale index to zero.

3. Declinating compass.—Select a point from which a point of known *Y*-azimuth can be seen. Set the zero of the azimuth scale exactly under the azimuth scale index. Using one of the methods described in paragraph 5 (preferably 5*c*), measure the azimuth to the distant point. For accurate results, repeat this operation three times. Subtract the average compass reading to the point from the known *Y*-azimuth to that point (adding 6400 mils to the known *Y*-azimuth, if necessary). The difference so obtained is the declination constant of the instrument. If more than one point of known *Y*-azimuth can be seen, similar readings are made for each point, the computation repeated for each, and the mean of the differences taken as the declination constant. Record the value on the instrument (with a china pencil on the mirror or with a pen on the edge of the case near the hinge). Check the constant at frequent intervals; repeat the declination for any new locality. This constant may be used in future work in one of two ways, as indicated in the following paragraph.

4. Use of declination constant.—*a.* The instrument may be used with the azimuth scale set as for declinating the instrument (zero under index). If used in this manner, a reading from the azimuth scale will be magnetic azimuth and the declination constant must be added to the reading to convert it to *Y*-azimuth.

b. A second method is to set the numerical value of the declination constant on the azimuth scale under the azimuth scale index with the azimuth scale adjuster. *Y*-azimuths then can be read from the instrument direct. In this case also, it is advisable to record the declination constant so that magnetic azimuths, if needed, can be computed and to permit resetting the azimuth scale if it is moved.

5. Measuring an azimuth.—In this paragraph all readings taken from the instrument are referred to simply as “azimuths.” This will be magnetic or *Y*-azimuth, depending upon which method described in paragraph 4 is being used for measuring.

a. Use at eye level, as in tall grass or brush:

(1) Incline the cover inward to an angle of about 800 mils with the case.

(2) Set the sight holder approximately perpendicular to the case.

(3) Stand in the position shown in figure 2, with the sight holder toward the body.

(4) Turn the front sight up until the point or opening comes into view through the rear sight.

(5) Aline the compass by sighting at the object across the points of or through the openings in the rear and front sights.

(6) Center the circular level bubble and read the azimuth scale at the black end of the needle by reflection in the mirror. This method can be used when light is poor. It has the disadvantages of a short sight base line, detracting from accuracy; leveling and orienting must be carried on simultaneously; the level of the eye must be moved from the sighting to the reading position, difficult to accomplish without disturbing the instrument position; and the reading of azimuths through a wide range of vertical angles is difficult.



FIGURE 2.—Use at eye level in poor light.

b. For same use as in *a* above (fig. 3):

(1) Incline the cover inward as in *a* (1) above.
 (2) Set the sight holder to a position in prolongation with the case.

(3) Set the rear sight perpendicular to the sight holder.

(4) With the circular level bubble centered, as indicated by the reflection in the mirror, and the sight holder pointed toward the eye, sight on the object through the rear sight and the cover window.

(5) Read in the mirror the azimuth scale at the black end of the needle. This method has the disadvantage that sighting in poor light is difficult. It has the advantages of a long sight base; sighting and reading can be done with the eye in one position; azimuths of objects at various elevations can be read by minor shifts in position of the instrument, or by varying the position of the sight holder, or by both.

- c. For accurate work when a stable stand is available (fig. 4):
- (1) Set the instrument on a stable stand.
 - (2) Open both cover and sight holder to the maximum, with both sights vertical, and the sight holder pointed toward the eye.
 - (3) Center the circular level bubble (using shims as necessary).



FIGURE 3.—Use at eye level, long sight base.



FIGURE 4.—Use on stand.

- (4) Sight on object through or over both sights, varying the position of one or both to accord with the height of the object sighted upon.
- (5) Without disturbing the position of the instrument, read the azimuth scale at the black end of the needle. This method gives the maximum sighting base, allows the needle to come to rest, and permits very accurate work.

d. When the object sighted is more than 260 mils below the operator (fig. 5):

- (1) Compass is held in the hands to place the sight holder toward the body.
- (2) Sight holder is inclined inward so that its reflection is seen in the mirror.
- (3) Object is sighted upon through the cover window.

(4) Object and the reflection of the slot in the sight holder must be bisected by the hairline and the circular level bubble centered when the reading is taken. The azimuth scale must be read at the black end of the needle.

e. When the object sighted is between 800 mils above and 260 mils below operator, he—

(1) Stands in the position shown in figure 6, with the instrument



FIGURE 5.—Object sighted is more than 260 mils below operator.



FIGURE 6.—Object sighted is between 800 mils above and 260 mils below operator.

cover opened toward the body, in such a position that the object can be seen in the mirror when the compass is level.

(2) Sets the sight holder approximately perpendicular to the case.

(3) Is certain that the compass is over the point, that the arms are pressed firmly against the sides, and that the feet are well placed.

(4) Levels the instrument with the circular level.

(5) Turns the body at the hips until the object can be seen in the mirror through the slot in the sight holder. The reflections of the object and of the slot in the sight holder both must be bisected by the hairline.

(6) Reads the azimuth scale at the *white* end of the needle. This reading is the desired azimuth. At the time the reading is taken, the object and slot must remain bisected by the hairline and the circular level bubble must be centered. With practice, it will be possible to read the center of the needle swing rather than wait for the needle to stop. This method has the following disadvantages: it is the only one in which the *white* end of the needle is read, and thus may introduce confusion; identification of object by means of its mirror image is difficult in poor light or on a distant object. Azimuths can be measured by the other methods given.

6. Measuring vertical angle (angle of site) (fig. 7).—The procedure is as follows:

a. Supported in the hand for rapid, approximate work—

(1) Incline the cover inward to an angle of about 800 mils with the case.

(2) Set the sight holder in prolongation of the case with the rear sight set at a right angle with the sight holder.

(3) Grasp the case with the thumb and forefinger of the right hand, cover toward the left with the sight holder pointed toward the eye. The middle finger of the right hand must touch the angle-of-site lever and be in a position to move it. The instrument is steadied by the left hand on the cover.

(4) The line of sighting is through the opening in the rear sight, and through the cover window. The object sighted must be bisected by the hairline and the rear sight. Care must be taken to hold the case in a vertical plane.

(5) In this position, the angle-of-site lever is moved with the middle finger until the tubular level bubble is centered.

(6) The instrument is then taken down and the reading of the angle-of-site index on the angle-of-site scale is taken. This is the desired vertical angle. It is minus when the index falls between zero and

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the cover hinge. It is well for new operators to take the average of several readings.

b. Instrument resting on stable support, the accuracy can be increased by—

(1) Using the method in *a* above, and resting the hand or instrument on a stable support.

(2) Using the method described below.

(*a*) Set the sights as in figure 4.

(*b*) Rest the instrument on a stable support, in a vertical plane, and sight through or over both sights.

(*c*) Have an assistant level the tubular level.

(*d*) Read the angle as in *a* above.



FIGURE 7.—Measuring site.

This latter method will provide a high degree of accuracy, but is slow.

c. For determining the possibility of clearing a mask, the required site can be set off on the angle-of-site scale; by sighting and leveling the bubble, the operator can then determine whether the required site clears the mask.

7. Use as clinometer and for running levels.—Set the sights as in figure 4. With the sight holder pointing toward the body, set the instrument in a vertical plane with the open face to the left. The machined surfaces on the lower edges of the case and the cover now form a plane approximately parallel to the tubular bubble when the angle-of-site index is set at zero.

a. Use as clinometer.—Set the machined surfaces on any incline (gun tube, gun axle, or taut measuring tape), center the tubular level bubble and read the angle opposite the angle-of-site index.

b. Use as a level, or for running levels.—Set the angle-of-site index at zero. The instrument now may be used for establishing levels, as when placed on a taut measuring tape, or for running levels by sighting through or over the sights.

8. Care.—The compass, M2, is easily damaged by shocks and mistreatment. It should be kept in the case when not in use and given the same care as any other delicate instrument. If it is allowed to get wet, it should be wiped dry as soon as possible, particularly at points where water could get into the case.

[A. G. 062.11 (3-27-42).] (C 1, April 22, 1942.)

BY ORDER OF THE SECRETARY OF WAR:

G. C. MARSHALL,
Chief of Staff.

OFFICIAL:

J. A. ULIO,
*Major General,
The Adjutant General.*

TECHNICAL MANUAL }
No. 6-220 }

WAR DEPARTMENT,
WASHINGTON, February 26, 1941.

FIELD ARTILLERY FIRE-CONTROL INSTRUMENTS

Prepared under direction of the
Chief of Field Artillery

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SECTION I GENERAL

	Paragraph
Fire-control instruments.....	1
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1. Fire-control instruments.—The optical fire-control instruments used in the field artillery are the aiming circle, battery commander's telescope, prismatic compass, range finder, and field glass. The principal nonoptical instruments are the alidade, plotting scale, protractor, straightedge, plane table, time-interval recorder, steel tape, thermometer, and declinator.

2. Definitions.—To understand the necessity for some of the features of these instruments, and their use, it is important to keep in mind the following:

a. Compass (magnetic) north is the north direction indicated by the magnetic needle of a compass.

b. Y-north (or grid north) is the north direction of the *Y*-line of a map or grid.

c. Azimuth, for field artillery purposes, is the angle measured clockwise from magnetic or *Y*-north, as the case may be.

(1) The *Y*-azimuth of any given line is the angle measured clockwise from *Y*-north to the given line. In commands to the executive of a firing battery, this direction is given as COMPASS (SO MUCH).

(2) The magnetic azimuth of a given line is the angle measured clockwise from magnetic north to the given line.

d. In general, the *Y*-north direction and the magnetic-north direction are not coincident. The declination constant (see fig. 7) of an instrument which has a magnetic needle is the clockwise angle from *Y*-north to the magnetic-north direction of the particular instrument concerned; this will vary for different localities and also for different instruments in the same locality. To declinate an instrument means to determine the declination constant of the instrument.

e. Compass instruments indicate azimuths only with respect to compass (magnetic) north. Therefore, to convert these readings to *Y*-azimuths, the declination constant must be applied to the compass reading.

SECTION II

AIMING CIRCLE, M1918 (FRENCH), AND M1 (NEW AMERICAN)

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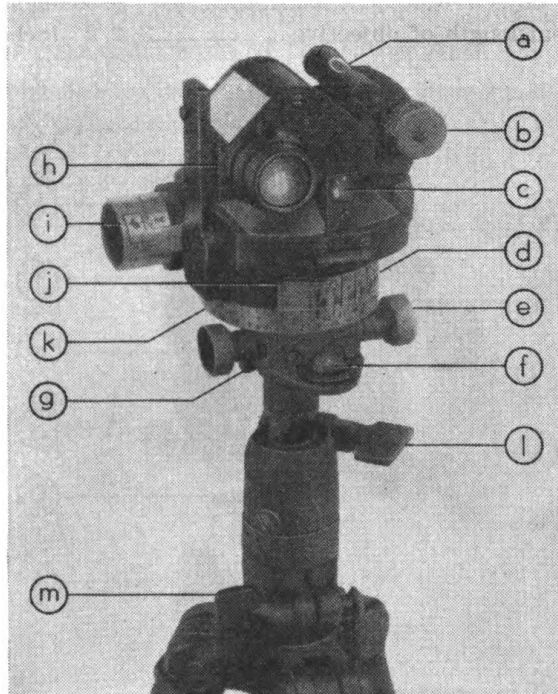
3. General.—*a.* The *aiming circle*, M1918 (French) or M1 (New American), is an instrument for use in measuring angles in azimuth and site, and for simple survey work. These two aiming circles are similar in operation. There are slight differences in construction. The structural differences will be noted in the appropriate places in this section.

b. The aiming circle consists of the aiming circle proper, the tripod, the instrument light, and the carrying case.

FIRE-CONTROL INSTRUMENTS

4. Aiming circle (figs. 1, 2, 3, and 4).—*a.* By unclamping the wing nut (g, figs. 1 and 2), the aiming circle proper may be rotated freely about, or removed from, the short vertical spindle whose lower ball-shaped end is mounted in a socket and secured by a clamping screw (l).

b. Telescope.—(1) The telescope is of the prismatic type, pivoted above the compass box, and moved through small vertical angles by the elevation knob. The eyepiece can be focused by rotation to suit



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| a. Level. | h. Lighting aperture. |
| b. Elevation. | i. Azimuth micrometer. |
| c. Prism. | j. Needle-release lever. |
| d. Plateau scale on upper dial. | k. Azimuth circle on lower dial. |
| e. Auxiliary azimuth-worm knob. | l. Clamping screw. |
| f. Spherical level. | m. Clamping screw. |
| g. Wing nut. | |

FIGURE 1.—Aiming circle, M1918 (French).

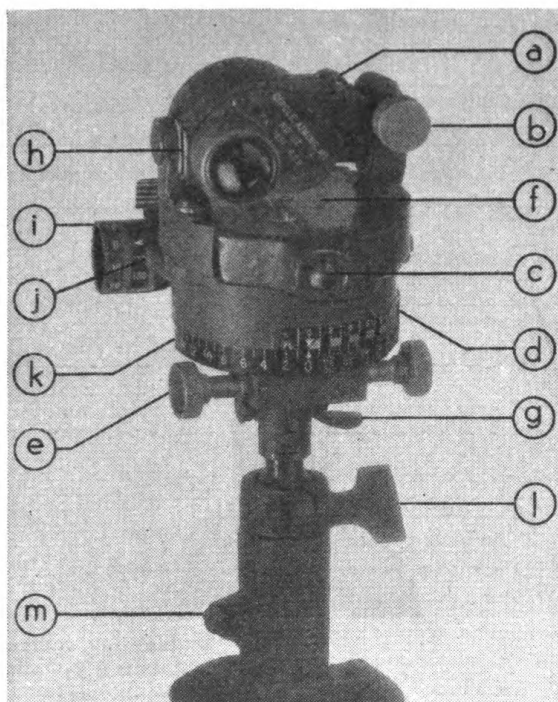
the observer's eye. A glass window is fitted into the body opposite the reticle so that the lines and scales on it may be illuminated. A level is mounted on the telescope body.

(2) The reticle of the M1918 (French) aiming circle contains a vertical mil-and-stadia scale. The mil scale is graduated, in 5-mil intervals, 100 mils on each side of the normal line (zero). The use of the stadia scale (on the right) is not contemplated, and it is not found on some instruments issued.

(3) The reticle of the M1 (New American) aiming circle contains a vertical and a horizontal mil scale. The scales are graduated, in 5-mil intervals, 85 mils on either side of the vertical and the horizontal lines.

(4) The telescopes have the following optical characteristics:

	<i>M1918</i>	<i>M1</i>
Field of view-----	12°	10°
Power-----	3.7	4.0
Diameter of exit pupil-----	.15 inch	.156 inch
Aperture of objective-----	.56 inch	.625 inch
Effective focal length of objective-----	2.2 inches	3.135 inches



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| a. Level. | h. Lighting aperture. |
| b. Elevation knob. | i. Azimuth micrometer. |
| c. Magnifier. | j. Needle-release button. |
| d. Plateau scale on upper dial. | k. Azimuth circle on lower dial. |
| e. Auxiliary azimuth-worm knob. | l. Clamping screw. |
| f. Spherical level (in compass box). | m. Clamping screw. |
| g. Wing nut. | |

FIGURE 2.—Aiming circle, M1 (New American).

c. On the lower dial is the azimuth circle, which is graduated into 64 equal spaces, each representing 100 mils of angle, and numbered clockwise from 0 to 64. The M1 aiming circle has an additional scale graduated from 0 to 32, with its zero at the 32 mark on the 0=64 scale. At the 0, 16, 32, and 48 graduations, indexes are engraved

which are used in connection with the plateau scale attached to the upper portion of the mount. These indexes are used only to read deflections for the French sight.

d. On the upper dial is the plateau scale (figs. 1, 2, and 4), which is used in conjunction with the graduations of the French sight, in the case of matériel so equipped. It consists of a quadrant subdivided into 200-mil spaces, each halved—one half plain and the other cross-hatched. Also, in the center of the left-hand division of the plateau scale (see fig. 8 ④) is an index for reading horizontal angles measured on the azimuth circle of the lower dial.

e. The azimuth micrometer (figs. 1, 2, and 4) is graduated into 100 equal spaces (numbered every ten) and contains two rows of figures. The outer row is numbered from 0 to 100; the inner row

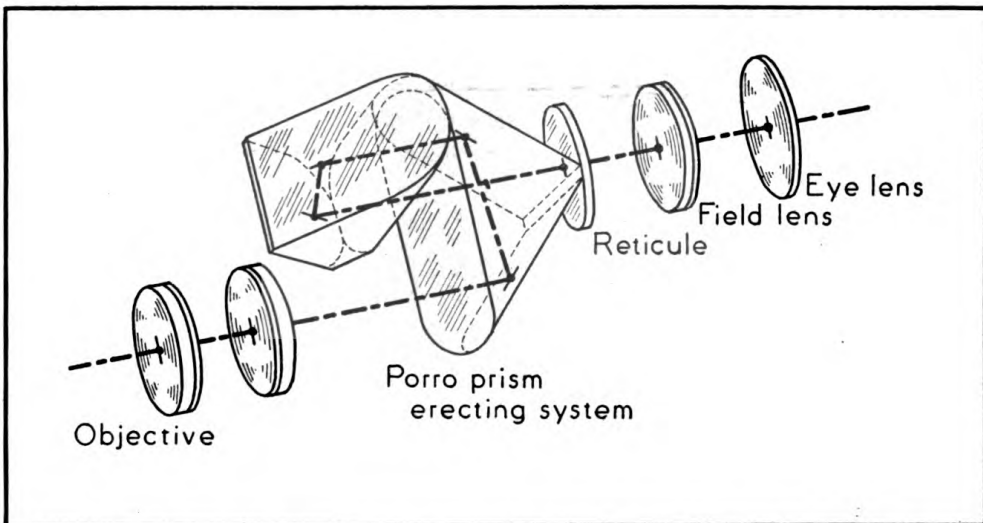


FIGURE 3.—Optical system of the aiming circle, M1918 (French).

100 to 200. There are also two indexes—one on a clear space for reading the outer row, and one on a cross-hatched area for reading the inner row. The clear index is used for measuring azimuths. When using the plateau scale, if an index at graduation 0, 16, 32, or 48 points to the clear space, the 0 to 100 graduations on the micrometer are used for obtaining 1-mil readings; whereas if an index points to the cross-hatched space, the 100 to 200 graduations are used. Where, within a plateau division, an index is exactly between the clear and the cross-hatched divisions, the micrometer reading is taken opposite its cross-hatched index. Where the index is exactly between two plateau divisions, the greater plateau reading is taken and the micrometer reading is taken opposite its clear index.

f. Between the upper dial, which carries the plateau scale, and the telescope is a compass box containing a compass (magnetic needle)

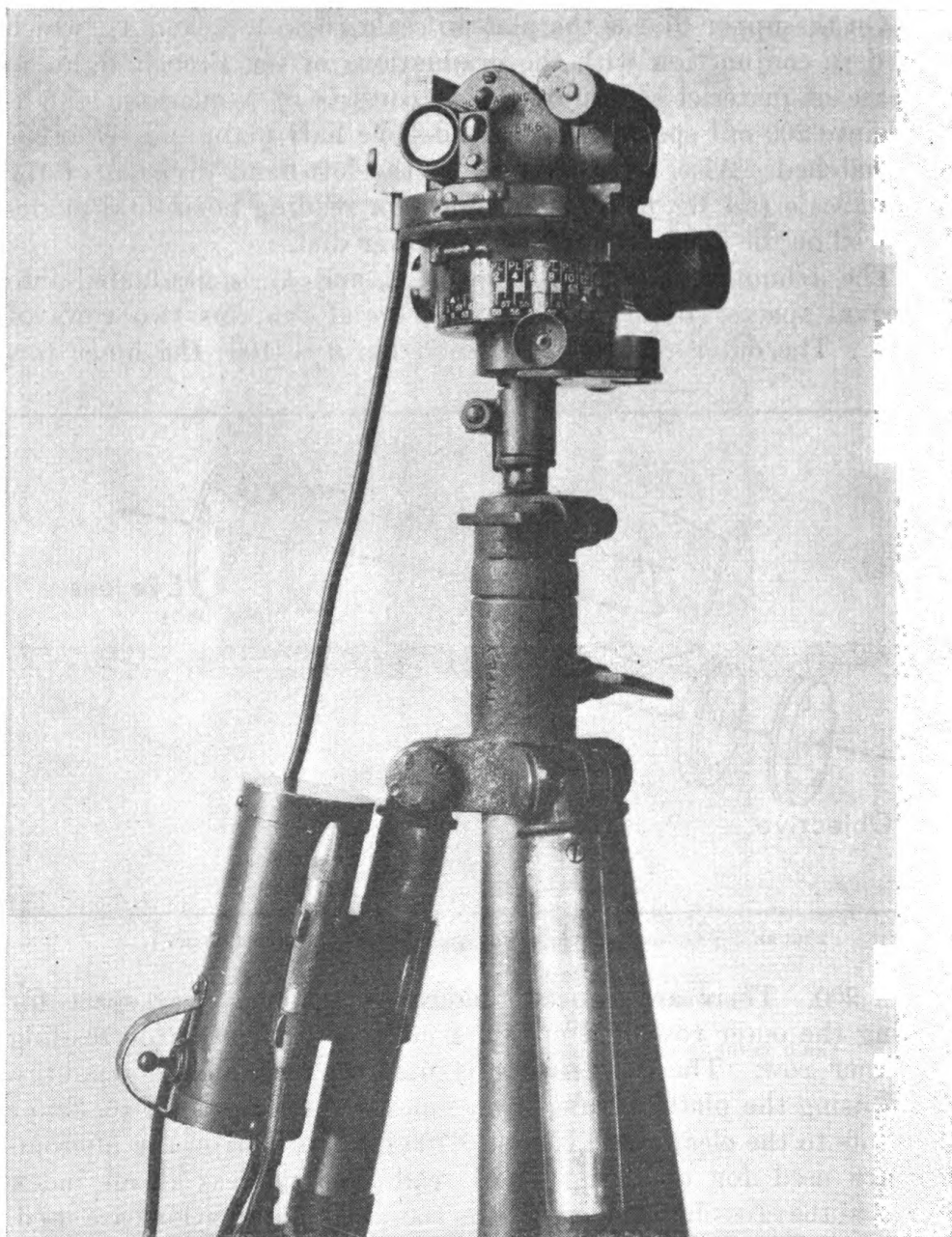


FIGURE 4.—Aiming circle with instrument light attached.

and a compass index. The compass needle may be clamped in position or released to rotate by means of the needle-release lever (j, fig. 1) for the M1918 or the needle-release button (j, fig. 2) for the M1.

g. The rotation of the entire aiming circle proper (both dials moving together) is effected by loosening the wing nut (g, figs. 1 and 2) and revolving the instrument freely by hand so as to point the telescope (line of sighting) in the approximate general direction desired. The wing nut is then tightened and the line of sighting pointed in accurate direction by turning the auxiliary azimuth-worm knob (e). Thus, there is a fast motion to obtain general direction and a slow motion for accurate adjustment. When it is desired to move the aiming circle proper through relatively small angles, only the slow motion (auxiliary azimuth-worm knob) is used. These two mechanisms, which move the entire aiming circle proper, are known and referred to as the lower motion.

h. From an examination of figure 8 it is evident that to measure horizontal angles the upper dial must be rotated while the lower dial remains fixed. A quick-release mechanism and the azimuth micrometer knob accomplish this. They are known and referred to as the upper motion.

i. Thus, the upper motion rotates as a unit the upper plate carrying the index of the azimuth scale, the line of sighting (telescope), and the compass box containing the needle and its index. The index of the needle and the index of the azimuth scale are coincident with the line of sighting.

j. Below the eyepiece of the M1918 telescope, a prism is provided for magnifying the end of the needle and its index, to facilitate reading.

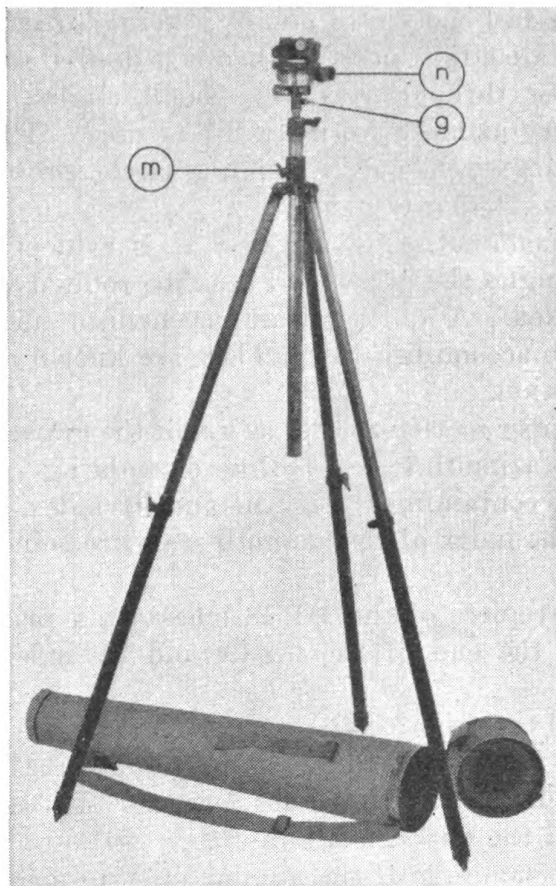
k. Attached to the front of the compass box of the M1 instrument is a magnifier to facilitate reading the position of the needle.

l. A spherical level is provided for leveling. Between the aiming circle proper and the tripod is a ball-and-socket joint. This permits leveling and the clamping of the aiming circle proper in position by clamping screw (l, figs. 1 and 2).

5. Lighting aiming circle at night.—*a. Instrument lights M2 and M4 (fig. 4).*—The instrument lights M2 (for the aiming circle M1) and M4 (for the aiming circle M1918), are similar in design and method of use. Each consists of a reticle unit, which may be attached to the left side of the telescope in position to illuminate the reticle; a finger light, attached to the battery case by a flexible cord, which is used to illuminate scales and bubbles of the instrument; and a battery case holding one BA-30 cell, which is provided with a clamp by means of which it is attached to a leg of the tripod. A toggle switch on the battery case turns the reticle and finger lights on or off simultane-

ously. A clip is provided on the side of the battery case for holding the finger light when not in use.

b. Care of instrument lights.—When the instrument light is attached to the aiming circle, it should be habitually turned off, except when in actual use. When the instrument light is in its carrying



- g. Wing nut.
- m. Clamping screw.
- n. Azimuth-worm knob.

FIGURE 5.—Aiming circle, M1918 (French), with tripod.

case, the BA-30 cell should be removed from the battery case and placed in the clip provided for the purpose, as deterioration of the cell while in the battery case may so damage the case as to make it useless.

6. Tripod (fig. 5).—The tripod is constructed of nonmagnetic metal and consists of three telescoping legs and the sliding vertical support which can be clamped in position by clamping screw (m).

7. Carrying case (fig. 6).—The carrying case for the aiming circle consists of three parts: the case proper, which is of metal, approximately cylindrical in shape, and contains the aiming circle proper and the tripod; an intermediate member, which serves the dual purpose of providing a cover for the case proper, and providing stowage space for the instrument light; and a cover for the instrument light compartment. The intermediate member contains clips and brackets for the instrument light; the BA-30 cell from the battery case, and one spare cell; and a leather case in which are two spare lamps.



FIGURE 6.—Carrying case for aiming circle with instrument light stowed for transport.

8. To set up instrument.—Extend the tripod legs and embed them firmly in the ground. Raise the sliding vertical support to the height desired and clamp by means of clamping screw (m, fig. 5); then level by means of the ball-and-socket joint and spherical level and clamp by means of clamping screw (l, figs. 1 and 2). To insure stability, the sliding vertical support should not be raised higher than necessary, preferably 6 inches or less.

9. To orient on magnetic north (figs. 1, 2, and 4).—To orient on magnetic north, rotate the needle-release lever, or button, to permit the compass needle to swing free. Set the azimuth circle to zero and loosen the wing nut; then rotate the instrument until the needle agrees approximately with the index. Clamp with the wing nut and complete accurate setting of the needle on its index by means of the lower

motion. This orients the zero of the azimuth scale on magnetic north. When so oriented, readings are taken by moving the line of sighting with the upper motion and are known as magnetic azimuth. To obtain more accurate results, the mean of several readings to an object should be taken, the needle each time being thrown off and centered anew on the index. If this mean is set on the azimuth scale and the

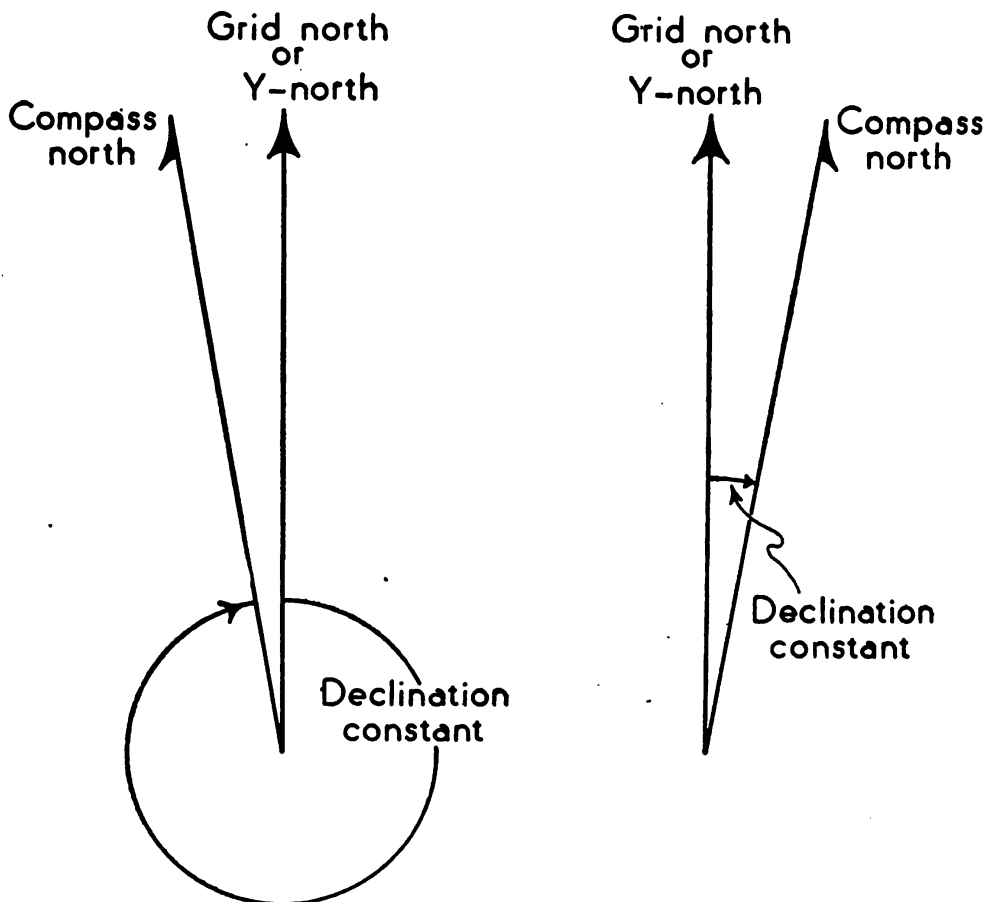


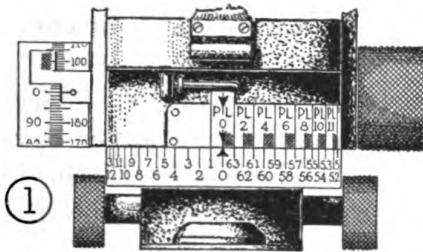
FIGURE 7.—Declination constant.

line of sighting directed on the object, the 0-3200 line of the instrument points to magnetic north.

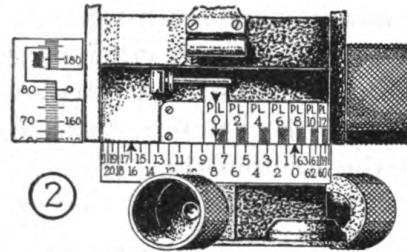
10. To declinate (fig. 7).—Set up the aiming circle over a point from which several points of known *Y*-azimuth can be seen. These points should lie in different quarters of the compass. Level the instrument carefully. Set the scale at zero and center the needle. With the upper motion turn successively to the known points and record the readings. Check by continuing around to the first point read; if the readings on this point differ by more than 1 mil, the measurements are thrown out and the readings are made again. Sub-

FIRE-CONTROL INSTRUMENTS

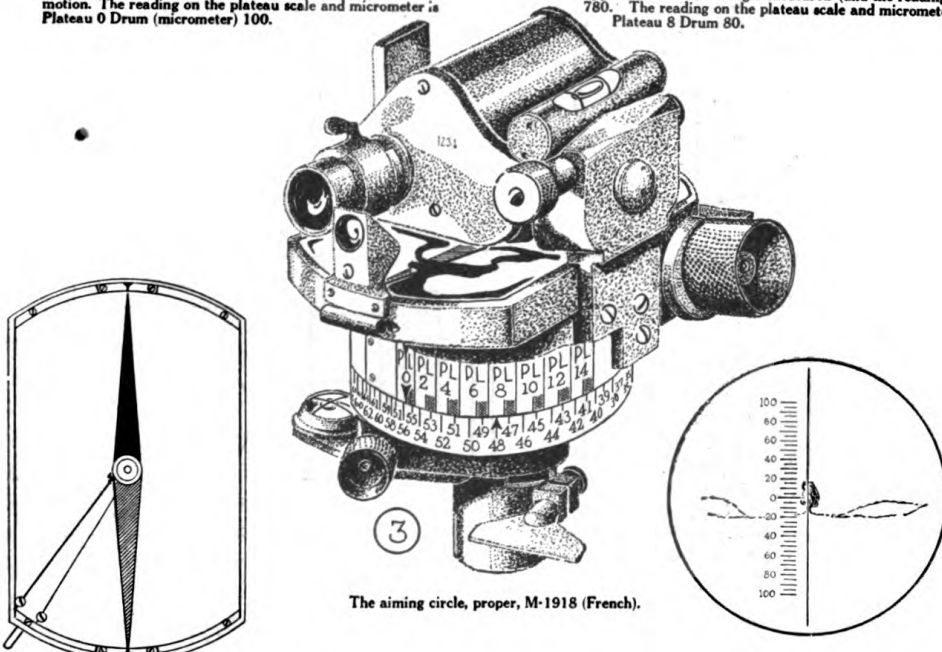
tract the compass reading (the mean of three readings) to each of the points from its known *Y*-azimuth. The average of the differences



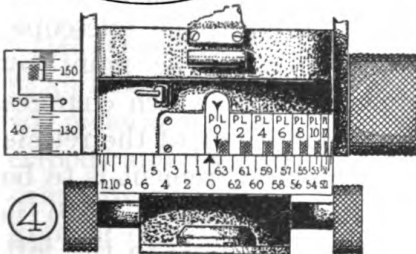
Indexes for the azimuth scale and the micrometer are set at zero; the vertical hair is laid on the target, using the lower motion. The reading on the plateau scale and micrometer is Plateau 0 Drum (micrometer) 100.



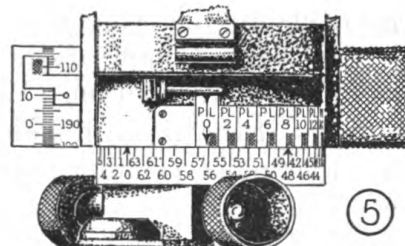
The vertical hair is moved to the aiming point, using the upper motion. The angle measured (and the reading) is 780. The reading on the plateau scale and micrometer is Plateau 8 Drum 80.



The aiming circle, proper, M-1918 (French).



The declination constant, 6350, is set on the scales, and the needle is centered, using the lower motion. The line of sighting is now on magnetic north; and the 0-3200 line is pointing at *Y*-north.



The vertical hair is now turned to the target (a small bush), using the upper motion. The reading is 5610—the clockwise angle (*Y*-azimuth) from *Y*-north to the target.

FIGURE 8.—Scales of the aiming circle, M1918 (French).

is the declination constant of the instrument. Record the value on the instrument. If the instrument is to be used in another locality, the declination constant again is determined for the new locality.

11. To orient on grid (Y) north (fig. 8 ④).—By means of the azimuth-worm knob set off the declination constant (par. 10) on the azimuth scale. Center the needle on the needle index by rotating the auxiliary azimuth-worm knob (lower motion). This orients the zero on the azimuth circle on grid (Y) north.

12. To measure a horizontal angle (fig. 8 ① and ②).—Set the index of the azimuth scale at zero by means of the upper motion and the micrometer. With the wing nut unclamped, turn the head of the instrument in the general direction of one of the points

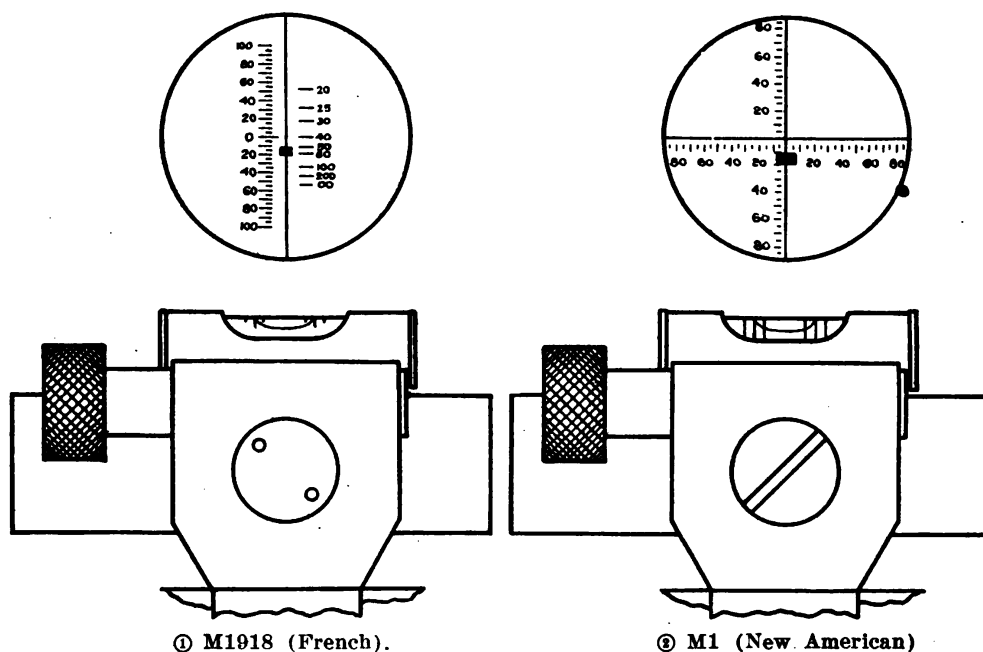


FIGURE 9.—Measuring site with the aiming circle.

(target), clamp the wing nut, and, sighting through the telescope, bring the vertical hair of the reticle accurately on the point by means of the lower motion. With the upper motion, which changes the settings of the azimuth scale, bring the vertical hair of the reticle on the other point (aiming point) to which the measurement is to be made. The reading of the azimuth scale and micrometer (780) is the angle desired. Had the aiming point been 780 mils to the left of the target instead of to the right, the reading would have been 5620 (6400-780). Thus the azimuth scale always indicates the clockwise angle from the 0-3200 line to the line of sighting. Before turning the telescope by means of the upper motion, care must be exercised that the wing nut is tightly clamped and, while turning it, that the position of the tripod is not disturbed.

13. To measure an angle of site (fig. 9).—Level the telescope by rotating the elevation knob (b, figs. 1 and 2) until the bubble is midway between the graduations on the level vial; then, sighting through the telescope, note on the reticle the reading that is level with the object whose angle of site is desired. The reading to the base of the object shown in the reticle in figure 9 is -20 mils.

14. Adjustment.—To adjust the azimuth micrometer, rotate the instrument until the index coincides with a graduation on the azimuth scale; loosen the locking nut, and rotate the azimuth micrometer until the zero coincides with the index; then tighten the nut securely.

15. Care.—When the instrument is not in use, the *compass needle should be lifted from the pivot by means of the needle-release lever or needle-release button*. To insure the proper telescoping of the tripod legs, care is taken to prevent their being dented.

SECTION III

AIMING CIRCLE, M1916 AND M1916M1

	Paragraph
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To set up instrument.....	18
To read magnetic azimuths.....	19
To declinate.....	20
To read Y-azimuths.....	21
Measurement of distance by stadia scale.....	22
To measure a horizontal angle.....	23
To measure an angle of site.....	24
Adjustments.....	25
Care and preservation.....	26

16. General.—The aiming circle, M1916 or M1916M1 (fig. 10), is an instrument for use in measuring angles in azimuth and site and for general survey work. It consists of the aiming circle proper, the tripod, and the carrying cases. The two models are generally the same except that the azimuth worm of the M1916 instrument has a knob at one end and a micrometer on the other end and the azimuth-worm throw-out lever is at the end of the worm toward the micrometer; for the M1916M1 instrument the azimuth worm has only a knob with the micrometer readings engraved thereon, and the azimuth-worm throw-out lever is located in proximity to the knob.

17. Aiming circle.—*a.* (1) The telescope is of the prismatic type with the optical system so arranged that the eyepiece is inclined normally 60° from the horizontal and can be rotated approximately

18° below and above this position by rotating the elevating-worm knob (1).

(2) It is provided with a reticle (fig. 11) graduated horizontally and vertically into 5-mil spaces, 25 mils on either side of the intersection of the diagonal lines, which intersection indicates the optical axis of the telescope. The outer horizontal graduations are numbered 25. The vertical lines begin at 25 mils from the intersection of the diag-

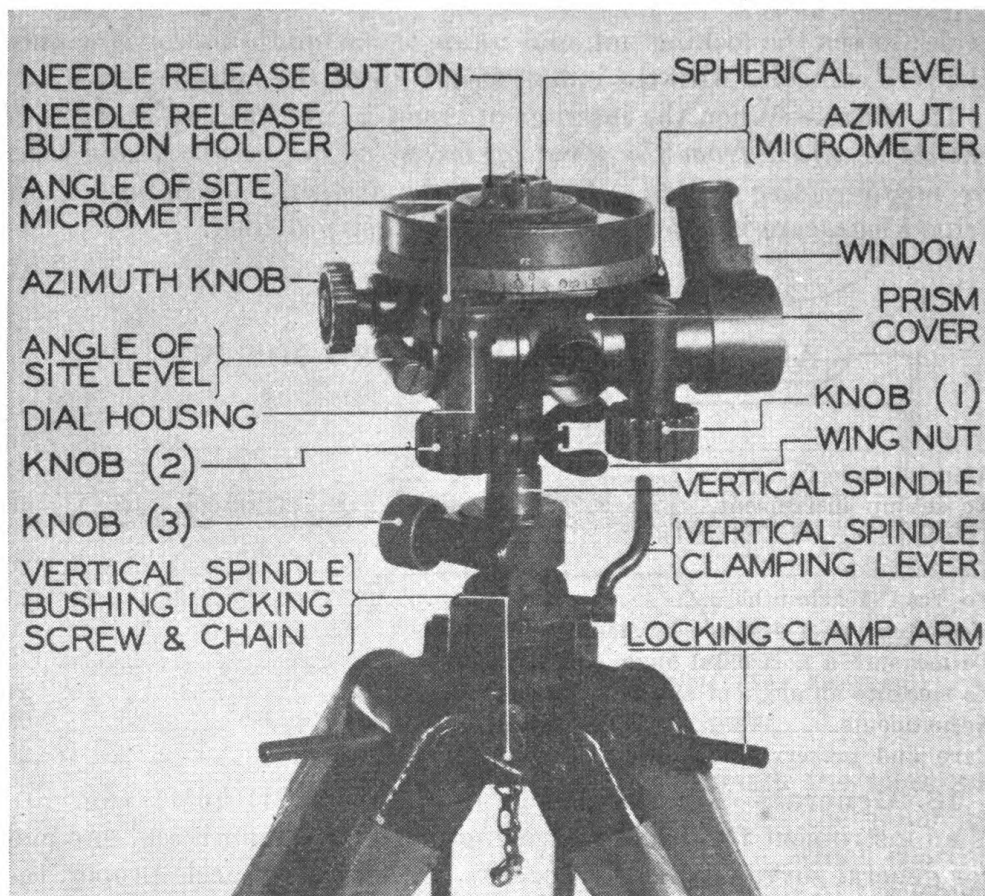


FIGURE 10.—Aiming circle, M1916.

onal lines. The instruments of later manufacture have reticles containing a vertical mil and stadia scale (fig. 12).

(3) The eyepiece tube is fitted with a glass window opposite the reticle for illuminating it when used at night.

(4) The optical characteristics are as follows:

Power.....	4
Field of view.....	10°
Diameter of exit pupil.....	.16 inch
Aperture of objective.....	.62 inch
Effective focal length of objective.....	2.15 inches

b. The angle-of-site mechanism is attached to and rotates with the telescope. The scale is graduated into six equal spaces, each representing 100 mils, and numbered from 0 to 6. The 3 graduation indicates the horizontal position of the line of site. The angle-of-site micrometer is graduated into 100 equal spaces, each representing one mil and numbered every 10 from 0 to 100. One revolution of the micrometer moves the angle-of-site index one space or 100 mils on the scale. This corresponds to the number of graduations on the micrometer.

c. The cylindrical compass box containing the needle carries the azimuth circle. The needle-release button is provided for raising

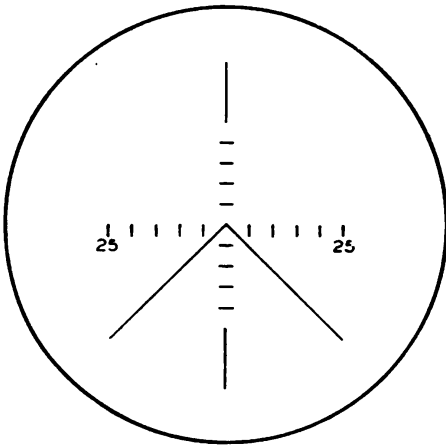


FIGURE 11.—Reticle graduations, aiming circle, M1916.

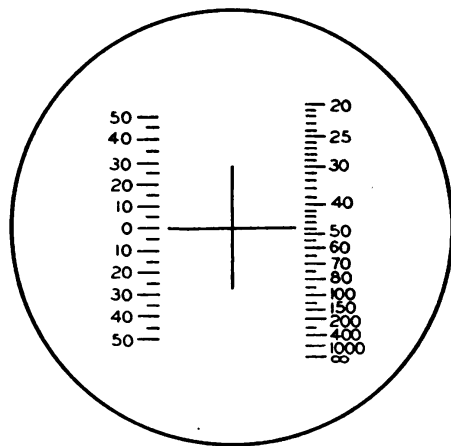


FIGURE 12.—Vertical mil and stadia scale, aiming circle, M1916.

or lowering the needle on the pivot and can be held down, to permit the needle to function, by rotating the needle-release button holder. A spherical level is housed in the raised portion of the needle-release mechanism.

d. The azimuth circle is graduated into 64 equal spaces, each representing 100 mils and numbered from 0 to 64. The azimuth micrometer is graduated into 100 equal spaces, each representing 1 mil and numbered every 10 from 0 to 100. One revolution of the micrometer advances the azimuth-circle index one space or 100 mils, which corresponds to the number of graduations on the micrometer.

e. The azimuth-worm throw-out lever, when rotated and held, disengages the azimuth worm from the worm wheel, permitting free rotation of the azimuth-circle and needle mechanism. With the azimuth worm engaged and the wing nut loosened, free rota-

tion of the instrument is obtained. Rotation of the orienting-worm knob ((3) fig. 10) rotates the spindle upon which the instrument is mounted; by this means fine adjustment is obtained for orienting purposes.

f. The lower portion of the vertical spindle inserted into the tripod head contains a ball-and-socket joint. When used in conjunction with the spherical level, this joint serves as a means for leveling.

g. Horizontal motion of the aiming circle may be obtained by two principal means, the lower motion and the upper motion. The lower motion consists of two parts, the fast motion and the slow motion. Fast motion for large changes is made by loosening the wing nut and turning the head about the spindle. Slow motion is obtained for accurate work by turning the orienting-worm knob ((3) fig. 10). The upper motion consists of two parts, the fast motion and the slow motion. Fast motion is obtained by use of the azimuth-worm throw-out lever. Slow motion is obtained by turning the azimuth knob. The readings on the scales of the instrument remain unchanged when the instrument is turned by means of the lower motion. Movement by means of the upper motion changes the reading of the scales.

18. To set up instrument.—Extend the tripod legs to the desired height and embed them firmly in the ground. Place the aiming circle on the vertical spindle, and clamp by means of the wing nut. Level by means of the ball-and-socket joint and spherical level, and clamp by means of the vertical-spindle clamping lever.

19. To read magnetic azimuths.—*a.* Rotate the needle-release button holder so as to allow the needle to swing free.

b. Loosen the wing nut and rotate the instrument until the needle marked *N* approximately coincides with the north index on the compass box; tighten the wing nut, and bring the needle and index to coincide exactly by means of the lower slow motion. The 0-3200 line of the aiming circle then indicates magnetic north.

c. With the upper motion, turn the intersection in the reticle to any object; the reading on the azimuth and micrometer scales is the magnetic azimuth from the instrument to the object.

20. To declinate.—This instrument is declinated as described in paragraph 10 for the French aiming circle.

21. To read *Y*-azimuths.—*a.* Proceed as in paragraph 19; to the magnetic azimuth, add the declination constant of the instrument; the sum is the *Y*-azimuth.

b. To read Y-azimuths directly.—(1) Lay the 0-3200 line of the aiming circle on magnetic north as in paragraph 19*a* and *b*. With the upper motion, measure the angle to some auxiliary point; to this angle add the declination constant, and with the upper motion set the sum on the scales; with the lower motion lay the intersection in the reticle back to the auxiliary point. The 0-3200 line of the aiming circle is now on *Y*-north.

(2) With the upper motion turn the intersection in the reticle to any object; the reading on the azimuth and micrometer scale is the *Y*-azimuth from the instrument to the object.

22. Measurement of distance by stadia scale.—To measure distance approximately by means of the stadia scale, a white rod with black bands exactly two yards apart is held upright at the point the distance to which is desired. Rotate knob ((1) fig. 10) until the infinity mark coincides with the lower mark on the rod; the graduation indicated by the upper mark is the distance to the point. One thousand yards is the greatest distance that can be measured with a 2-yard rod.

23. To measure a horizontal angle.—With the upper motion, set the indexes of the azimuth and micrometer scales at zero. With the wing nut unclamped, turn the head of the instrument in the general direction of one of the points (target), clamp the wing nut, and, sighting through the telescope, bring the intersection in the reticle accurately on the point by means of the lower slow motion. With the upper motion bring the intersection in the reticle on the other point (aiming point) to which the measurement is to be made. The reading of the azimuth and micrometer scales is the angle desired. Care must be exercised that the wing nut is tightly clamped before turning the telescope by means of the upper motion, and, while turning it, that the position of the tripod is not disturbed.

24. To measure an angle of site.—Turn the elevating-worm knob until the intersection in the reticle is exactly on the point whose angle of site is desired. Level the angle-of-site bubble by means of the angle-of-site worm knob ((2) fig. 10). The reading on the site and micrometer scales will be the required angle of site.

25. Adjustments.—To adjust the azimuth micrometer, rotate the azimuth circle until the index coincides with a graduation, then loosen the azimuth-micrometer locking screw and rotate the micrometer until the zero coincides with the index; then tighten the screw. The angle-of-site scale and micrometer are adjusted in the shop so that when the index indicates 3 and the micrometer 0 the line of site is horizontal. To adjust the angle-of-site micrometer, set the index to coin-

cide accurately with the 3 graduation, loosen the angle-of-site micrometer retaining screw, and rotate the micrometer until the 0 coincides with the index; then tighten the screw.

26. Care and preservation.—Before inserting the instrument in its carrying case, cover the objective prism by rotating the prism cover downward. Raise the compass needle from the pivot by rotating the needle-release button holder until the needle-release button is free. Care should be taken that the vertical spindle is not dented, marred, or otherwise damaged.

SECTION IV

BATTERY COMMANDER'S TELESCOPE, M1915

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Tripod.....	30
Lighting battery commander's telescope at night.....	31
Carrying cases.....	32
To set up instrument.....	33
To measure a horizontal angle.....	34
To measure an angle of site.....	35
Adjustment.....	36
Care.....	37

27. General.—The battery commander's telescope, M1915 (figs. 13 and 14), is a binocular observing instrument. It is primarily an instrument for the observation of fire, but is habitually used also for measuring horizontal and vertical angles in the calculation of firing data. It consists of the telescope proper, the azimuth mount, the tripod, the instrument light, and the carrying cases.

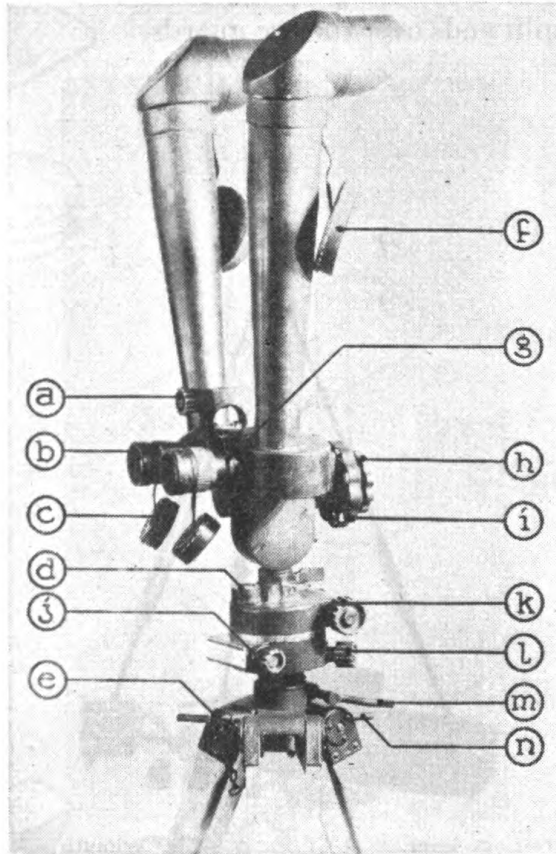
28. Telescope.—*a. General.*—(1) The telescopes are mounted on a common pivot, free to rotate laterally from the vertical to the horizontal position. They can be locked by the telescope clamp knob. The telescopes are placed in the horizontal position for stereoscopic vision; in the vertical position for periscopic vision.

(2) Both telescopes contain similar optical systems (fig. 15) so arranged as to space the eyepieces approximately 12 inches from the objective prisms. The distance between the objective prisms is about ten times that between the eyepieces when the telescopes are horizontal, which causes the objects viewed to be brought into strong relief, unless too far distant.

(3) The telescopes, rotating about a common hinge, permit adjustments for interpupillary distance; a scale, graduated every 2

millimeters from 60 to 70 for both the vertical and horizontal positions of the telescopes, permits the observer to set rapidly for the spacing of his eyes when the interpupillary distance in millimeters is known.

(4) The eyepieces can be focused independently for each eye by screwing them in or out, and are provided with a diopter scale for



- | | |
|---|-------------------------------------|
| a. Angle-of-site micrometer. | h. Elevation knob. |
| b. Eye guard. | i. Telescope clamp knob. |
| c. Eyepiece cap. | j. Azimuth adjusting-worm knob. |
| d. Spherical level. | k. Azimuth-worm knob. |
| e. Vertical-spindle bushing locking screw, and chain. | l. Azimuth clamp. |
| f. Objective cap. | m. Vertical-spindle clamping lever. |
| g. Reticle adjusting ring. | n. Locking-clamp arm. |

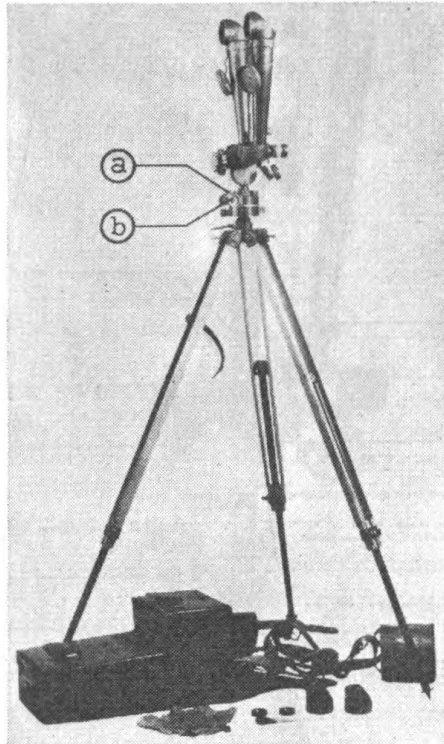
FIGURE 13.—Battery commander's telescope, M1915.

rapid setting when the observer knows the correction for his eyes. The zero graduations are the settings for normal eyes.

(5) The right-hand telescope contains a reticle (fig. 16) bearing a horizontal and a vertical line, forming a cross which indicates the optical axis of the telescope. Above the horizontal line are

two short lines spaced 3 mils apart, which are for use in noting the height of burst. Horizontal graduations at 5-mil intervals 30 mils on each side of the vertical line are also provided. The reticle can be erected to suit the position of the telescope by rotating the reticle adjusting ring.

(6) Ray filters are supplied for use when observing into the glare of the sun or a searchlight, and are attached to the eyepieces by pushing the split ends over the eye guards.



a. Throw-out lever.

b. Azimuth micrometer.

FIGURE 14.—Battery commander's telescope, M1915, with tripod and carrying cases.

(7) The optical characteristics are as follows:

Power.....	10
Field of view.....	4.25°
Diameter of exit pupil.....	.18 inch
Clear aperture of objective.....	1.78 inches
Effective focal length of objective.....	11.55 inches

b. Azimuth scale (fig. 17).—(1) The telescope, when mounted on the azimuth mount, has movement in elevation and azimuth and is controlled by the elevation and the azimuth-worm knobs. The amount of elevation or depression can be read on the angle-of-site mechanism.

The azimuth mount of the battery commander's telescope is assembled integrally with its tripod for carrying (par. 30), but is discussed here

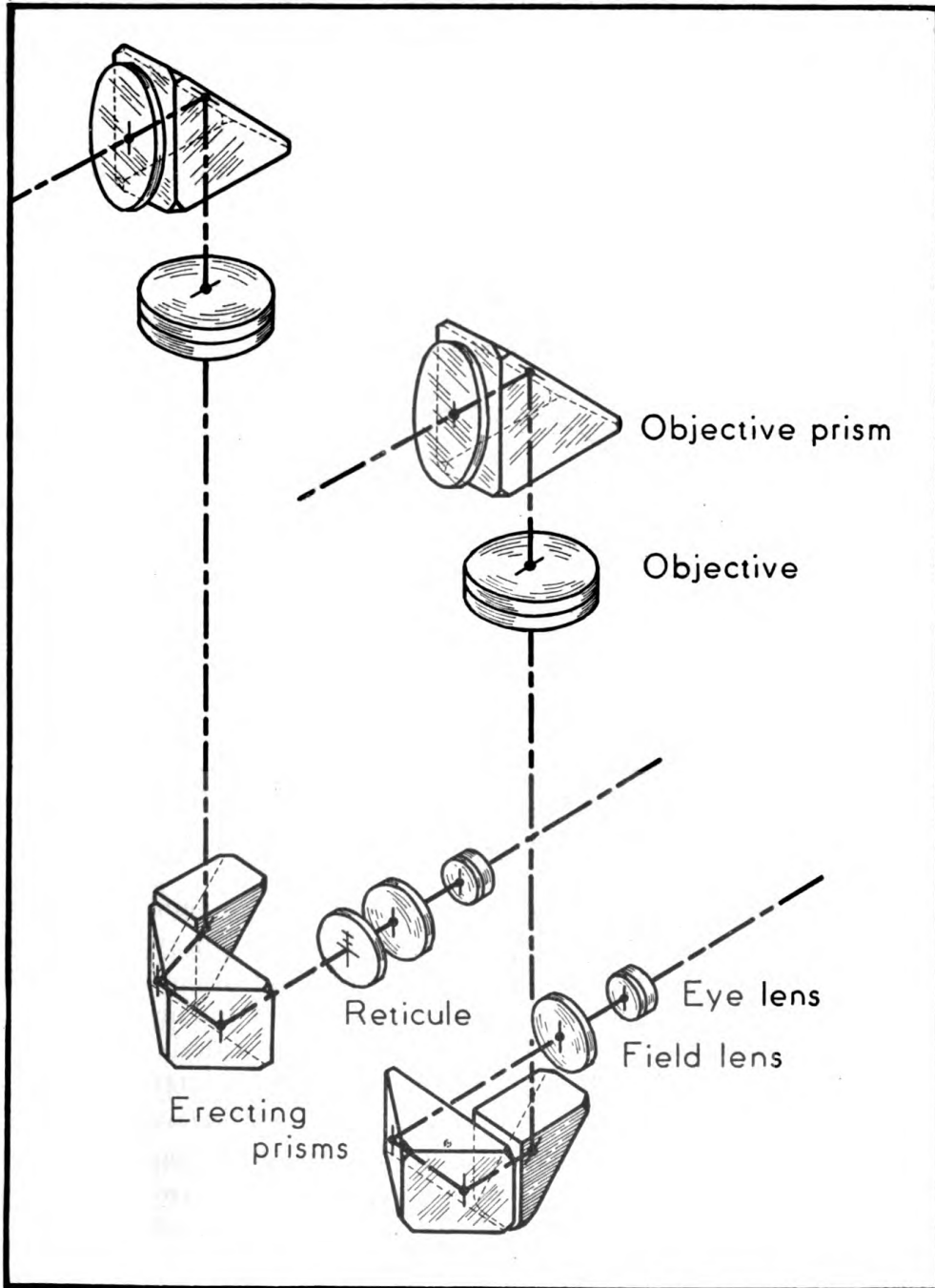


FIGURE 15.—Optical system of the battery commander's telescope, M1915.

as being an operating component of the telescope proper. The lower end of the elevation-worm wheel contains a hole and tapered seat for

mounting on the spindle of the azimuth mount, and is retained in position by the locking plunger.

(2) The azimuth circle is graduated into 64 equal spaces, each representing an angle of 100 mils, and numbered from 0 to 64.

(3) The azimuth micrometer is graduated into 100 equal spaces, each representing 1 mil, and numbered every 10 spaces from 0 to 100. One revolution of the micrometer moves the azimuth index 1 space (100 mils), which corresponds to the number of graduations on the micrometer.

(4) The throw-out lever, when rotated and held, disengages the azimuth worm from the teeth on the worm wheel, permitting free rotation of the upper portion of the mount which carries the telescopes and azimuth index. With the azimuth worm engaged and the

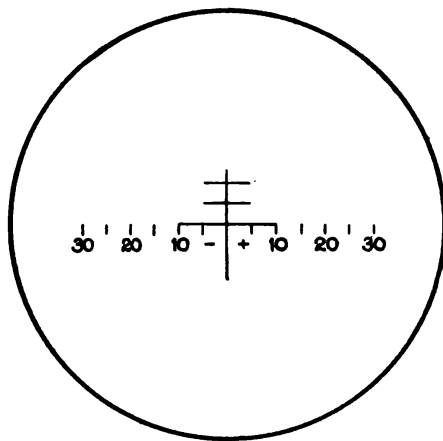


FIGURE 16.—Reticle graduations of the battery commander's telescope, M1915.

azimuth clamp loosened, free rotation of the entire mount and telescope is obtained. Rotation of the azimuth adjusting worm knob causes movement of the azimuth circle and the upper portion of the mount, by which means fine adjustment is obtained for orienting.

c. Angle of site (fig. 18).—(1) The angle-of-site scale is graduated into six equal spaces, each representing an angle of 100 mils, and numbered from 0 to 6. The 3 graduation indicates the level position.

(2) The angle-of-site micrometer is graduated into 100 equal spaces, each representing 1 mil, and numbered every 10. One revolution of the micrometer moves the angle-of-site index 100 mils, which corresponds to the number of graduations on the micrometer.

29. Azimuth mount (figs. 13 and 14).—The lower portion of the azimuth mount, inserted into the tripod head, contains a ball-and-socket joint, which, when used in conjunction with the spherical

level attached on the top of the mount, serves as a means for leveling.

30. Tripod (figs. 13 and 14).—*a.* The tripod for the battery commander's telescope is that known as type G.

b. The legs consist of two sections.

(1) The upper sections are pivoted to the tripod head and may be clamped, to prevent the legs from spreading, by means of the locking-clamp arm.

(2) The lower sections consist of steel tubes, which slide freely through the lower portions of the upper sections and may be clamped

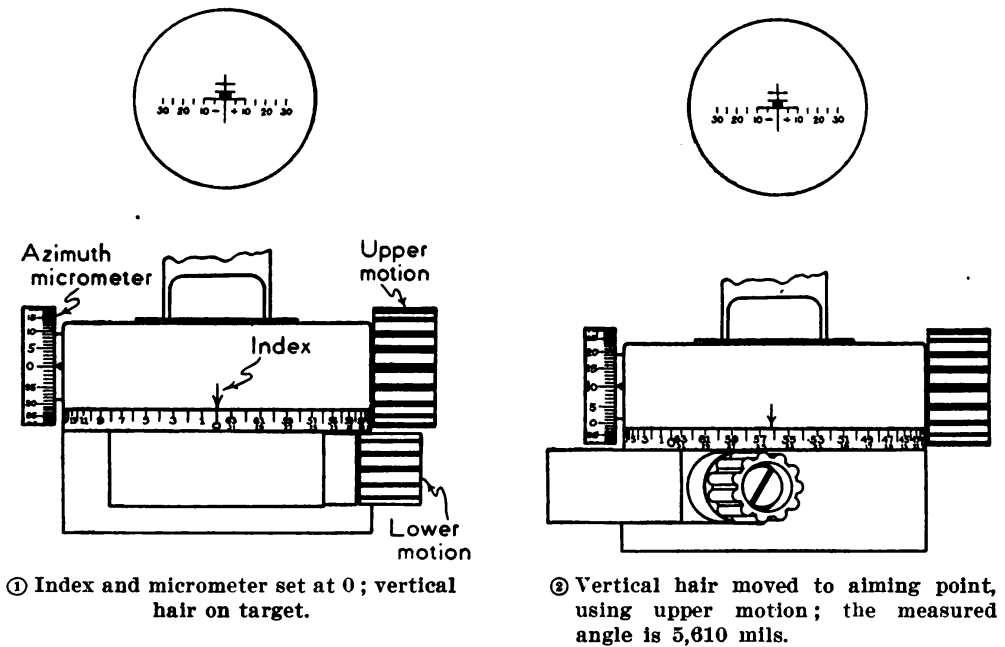


FIGURE 17.—Measuring a horizontal angle with the battery commander's telescope, M1915.

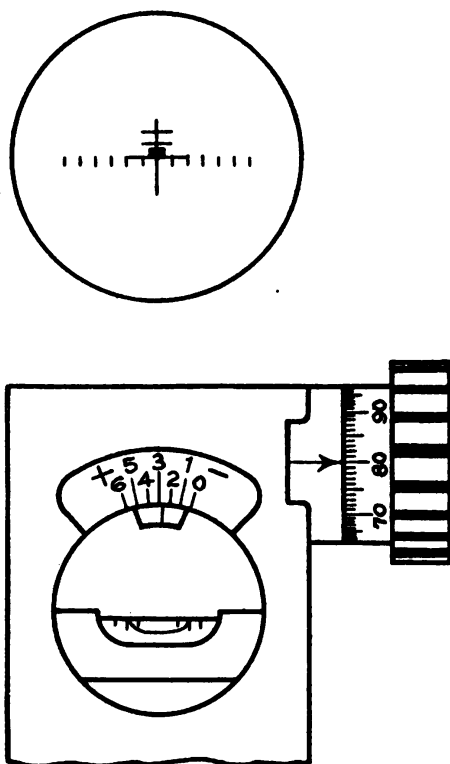
by means of the wing nuts. Pointed shoes, driven in the lower ends, permit embedding the legs in the ground.

c. The tripod head contains a split steel bushing, which may be constricted by means of the vertical-spindle clamping lever for clamping the ball-and-socket joint of the azimuth mount.

d. The azimuth mount remains assembled to the tripod head when placed in the tripod carrying case.

31. Lighting battery commander's telescope at night.—*a.* *Instrument light M1* (fig. 19).—The instrument light M1 consists of a battery case and a lamp housing for the reticle lamp projecting from the bottom of the battery case. The open end of the lamp house is cut on the same radius as the reticle ring, and when the unit is clamped on the right-hand telescope tube, it is positioned by the lamp house

fitting snugly over the reticle ring. The reticle ring is provided with glass covered windows to permit illumination of the reticle. A finger light, connected to the battery case by a flexible cord, provides a means to illuminate the scales and bubbles of the instrument. A clip is provided on the side of the battery case to hold the finger light when not in use. The battery case, which holds one BA-30 cell, is provided with a clamp for attachment to the right-hand telescope tube; and



The angle-of-site reading shown above is 280. The target, therefore, is 20 millimeters (300-280) below the horizontal.

FIGURE 18.—Measuring site with the battery commander's telescope, M1915.

has, at its lower end, a switch which permits the reticle lamp and finger light to be turned on or off simultaneously.

b. Care of the instrument light.—When the instrument light is attached to the battery commander's telescope, it should be habitually turned off, except when in actual use. When the instrument light is in the carrying case, the BA-30 cell should be removed from the battery case and placed in the clip provided for the purpose, as deterioration of the cell while in the battery case may so damage the case as to make it useless.

32. Carrying cases.—The carrying case for the battery commander's telescope is of leather, with wood-reinforced recesses so fixed as to hold the instrument immovable and guard it from shock. Compartments are provided for visors and ray filters. Clips are provided for the instrument light M1, two BA-30 cells, and there is a bracket

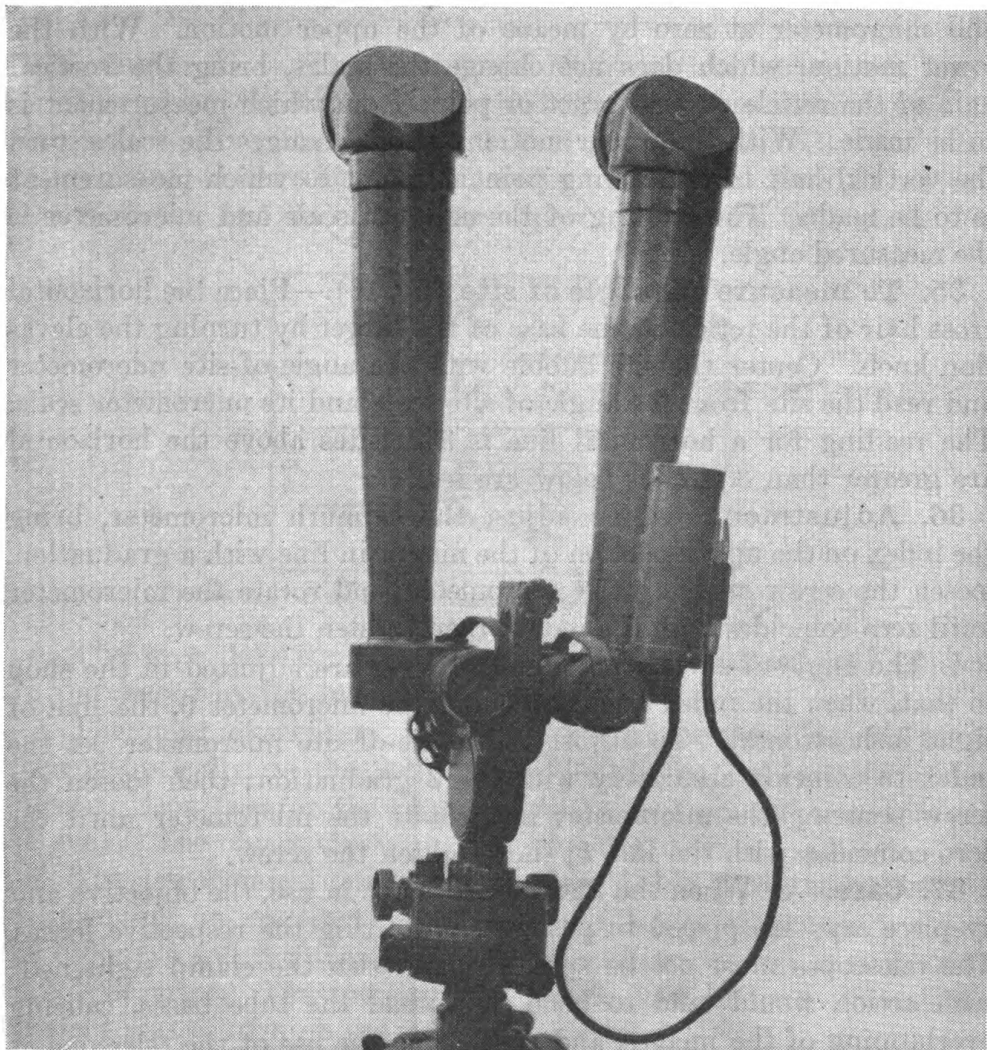


FIGURE 19.—Battery commander's telescope with instrument light attached.

to hold two spare lamps. The case has two closing straps and, at one end, a heavy leather carrying flap for attachment to a saddle. The carrying case for the tripod is an arrangement of leather straps provided with reinforced leather boots at both ends and a leather sling for carrying from the shoulder.

33. To set up instrument (figs. 13 and 14).—Extend the tripod legs to the desired height and embed them firmly in the ground. Place the telescope on the vertical spindle, and lock. Level by means of the ball-and-socket joint, and clamp in position by means of the vertical-spindle clamping lever.

34. To measure a horizontal angle (fig. 17).—Set the index and micrometer at zero by means of the upper motion. With the lower motion, which does not change the scales, bring the vertical hair of the reticle on the target or point from which measurement is to be made. With the upper motion, which changes the scales, turn the vertical hair to the aiming point or point to which measurement is to be made. The reading of the azimuth scale and micrometer is the measured angle.

35. To measure an angle of site (fig. 18).—Place the horizontal cross hair of the reticle at the base of the target by turning the elevation knob. Center the site bubble with the angle-of-site micrometer and read the site from the angle-of-site scale and its micrometer scale. The reading for a horizontal line is 300; sites above the horizontal are greater than 300, sites below are less.

36. Adjustment.—*a.* To adjust the azimuth micrometer, bring the index on the upper portion of the mount in line with a graduation, loosen the screw securing the micrometer, and rotate the micrometer until zero coincides with the index; then tighten the screw.

b. The angle-of-site micrometer and scale are adjusted in the shop so that, when the index indicates 3 and the micrometer 0, the line of sight is horizontal. To adjust the angle-of-site micrometer set the index to coincide accurately with the 3 graduation; then loosen the screw securing the micrometer and rotate the micrometer until the zero coincides with the index; then tighten the screw.

37. Care.—*a.* When the instrument is not in use, the objective and eyepiece caps are placed in position, protecting the respective lenses. The telescopes must not be spread apart with the clamp tightened; such action would tend to bend or spread the tube bases, causing overlapping of the images, and preventing the use of the telescope as a binocular instrument.

b. The vertical spindle on the azimuth mount must be carefully protected from injury and dents, which would make the assembly of the telescope mount difficult. It should be kept slightly oiled to prevent the formation of rust.

SECTION V

FIELD GLASSES

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Field glass, type EE.....	41

38. General.—*a.* The field glass is an optical instrument used for observation, especially of fire, and for the measurement of small horizontal and vertical angles. A field glass is essentially two telescopes mounted together for binocular vision. No item of an artillery officer's equipment is more important than his field glass.

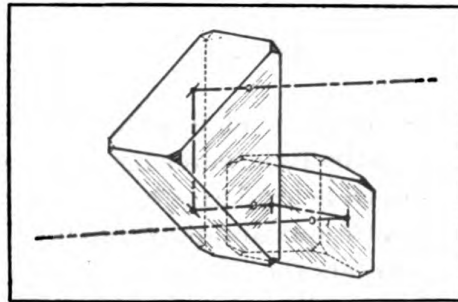


FIGURE 20.—Field glass—trace of image through Porro prism.

b. The type EE is the standard for issue. Other field glasses are purchased by the individual.

c. The most elementary form of telescope, as well as the most efficient optically, is the astronomical telescope. It consists of an objective lens (nearer the object viewed), and an eye lens (nearer the eye). The object viewed is seen inverted.

d. The astronomical telescope is converted to a terrestrial telescope by inserting an erecting system either of lenses or prisms between the objective and the eyepiece, so that the object viewed is seen uninverted or erect. The terrestrial telescope now is used universally for field glasses of high grade.

e. Prisms (fig. 20) now are used exclusively in military field glasses to erect the image, for the following important reasons:

(1) The length of the telescope is reduced greatly, since the light is turned back on itself twice in passing between the objective and the eyepiece.

(2) The prisms can be so arranged as to separate the objectives of the two telescopes considerably more than the eyepieces, thus increasing the stereoscopic effect (par. 39*e*).

39. Optical characteristics.—*a. General.*—The optical characteristics of a field glass are dependent upon the purpose and conditions under which the glass is to be used. Weight is an important consideration in many cases. Other things being equal, a saving in weight can be effected only by sacrificing optical qualities. The artillery officer selects his field glass ordinarily with a view of obtaining the highest possible optical qualities.

b. Power.—The power of a telescope is the number of times it magnifies the object viewed. Example: With a 6-power telescope, an object 600 yards distant appears as it would to the naked eye at a distance of only 100 yards.

c. Illumination.—(1) Without illumination, an object cannot be seen however great its size. The quantity of light or number of luminous rays which enter a telescope depends solely on the size of the objective, or, strictly speaking, the effective aperture of the objective.

(2) Because of imperfections in design, material, and workmanship, a certain portion of the light entering a telescope is lost in passing through it. In modern field glasses of high grade, however, these losses have been minimized and are quite small.

(3) The light which enters the telescope, and which is not absorbed internally, may be utilized, relatively speaking, in one of two ways—if the power is low, the light illuminates brightly a small image; if the power is high, the light illuminates dimly a large image. Thus power and illumination, both essential in a telescope, are conflicting characteristics. With a given objective, power is obtained at the expense of illumination. If it is desired to increase the power and still retain good illumination, it is necessary to increase the objective.

(4) The rays emerge from the eyepiece from what is known as the exit pupil, which can be seen as a luminous circle by looking at the eyepiece from a distance of about 8 inches. The diameter of the exit pupil is the quotient of the effective aperture of the objective divided by the power. When the exit pupil is substantially the same size as the pupil of the eye, the image is as bright as possible; when the exit pupil is smaller, the illumination is deficient; when the exit pupil is larger, there is no gain in illumination as compared with an exit pupil of the same size as the pupil of the eye.

(5) The pupil of the eye distends and contracts to meet the attendant light conditions. The diameter is stated generally as from .06 to .08 inch in sunlight, and from .20 to .25 inch at dusk. For military purposes, it is desirable to have an exit pupil approaching .20 inch, in

order that the field glass may be illuminated fully even under unfavorable light conditions.

(6) Thus, in order to secure full illumination, it is desirable to confine the power to five (1 divided by .20) per inch of effective aperture of the objective; or the power should be about the diameter divided by .20. The larger the objective, the greater, in general, are the weight and size of the field glass. It follows that high power and adequate illumination necessitate a relatively heavy and large field glass.

(7) The illumination is expressed by the square of the diameter of the exit pupil, generally in millimeters.

d. Field of view.—(1) The construction of the eyepiece is such that its field of view ordinarily is limited to about 900 mils. Certain eyepieces now are being manufactured which have a field of view of about 1,200 mils.

(2) The field of view of a telescope is the angle which may be viewed at one time; its value is the quotient of the field of view of the eyepiece divided by the power. It follows that, for a given eyepiece, a large field of view can be obtained only at a sacrifice of power.

e. Stereoscopic effect.—(1) Stereoscopic effect, in binocular vision, is the direct perception of the relative distance of objects, of their size, and of their shape, other than in a plane perpendicular to the line of vision. When an object is viewed with one eye, there is no perception of its distance other than by a comparison, more or less unconscious, of its apparent size with its known size; or by some similar means. In binocular vision, however, there is increased perception of the character of the object, because of the separation of the eyes. The distance between the centers of the pupils of the eyes is called the interpupillary distance, generally stated in millimeters; it varies with the individual.

(2) When an object is viewed with a binocular observing instrument whose objectives are separated more than the eyes, the stereoscopic effect of the naked eyes is augmented, because of the distance between the objectives.

(3) The stereoscopic effect is greater for near objects than for distant ones. The power of a field glass may be considered as bringing the object nearer, so that the stereoscopic effect is increased also by the power.

(4) The stereoscopic power of a field glass is the gain in stereoscopic effect afforded by the instrument as compared with that of the naked eyes. It is expressed by the ratio of the interobjective

distance to the interpupillary distance, multiplied by the power of the field glass; it is about 16 for an 8-power field glass.

f. Selection of a field glass.—(1) It may be stated with reference to power—

(a) High power decreases the field of view.

(b) High power increases the diameter of the objective necessary for proper illumination; and hence increases the weight and size of the field glass.

(c) When not using a fixed support, a field glass of high power is more difficult to hold sufficiently steady for satisfactory observation than is one of lower power.

(d) A field glass of high power or poor illumination tends to tire the eyes, particularly when used continuously or under adverse conditions of observation.

(e) Tests at the Field Artillery School have demonstrated that the 8-power field glass is the most efficient for observation by day, under average conditions, including a wide range of extremes; and that powers of 6 and 7 also are very satisfactory. Powers higher than 8 are less satisfactory for use without a fixed support.

(2) If a field glass of small size and weight is desired, it is necessary to sacrifice either power or illumination, both of which are desirable optically.

40. Mechanical features.—*a. General.*—As a result of experience, the following features are accepted generally as desirable in a military field glass:

(1) Frame compact, strong, light, durable, and noncorrosive.

(2) Optical parts, so far as possible, moistureproof and dustproof.

(3) Construction such that the field glass can be disassembled, cleaned, and repaired only with special facilities and by expert workmen, thereby preventing promiscuous tampering.

b. Mil scale.—(1) In commercial glasses of approved type, one of the telescopes (usually the right) has a reticle which carries a scale graduated horizontally and vertically in mils permitting the measurement of angles within the field of view. The scales found in issue glasses are discussed in paragraph 41a.

(2) The scale should be placed accurately in the plane of the image formed by the objective; otherwise, there is movement of the image with respect to the scale as the eye is moved laterally at the eyepiece—a condition called parallax. The positive elimination of parallax for all distances complicates construction seriously and is necessary only in accurate surveying instruments. In the field glass, the scale and the objective both are fixed in position so as to eliminate parallax

under average conditions of use. The parallax under other conditions is of negligible consequence.

(3) The mil scale should be placed correctly, at the time of purchase, for the interpupillary distance of the owner.

c. Use.—(1) *Observation.*—When using a field glass, it should be held in both hands, lightly pressed to the eyes, so as to keep the relation with the eyes constant, but not so as to transmit tremors of the body. When possible, it is best to use a rest for the glass or elbows.

(2) *Angle measurement* (fig. 21).—If an angle is small it may be measured by the mil scale in the field glass. A horizontal angle of 1,600 mils may be measured by looking at the target and then having another person sight across the front of the glass (perpendicu-

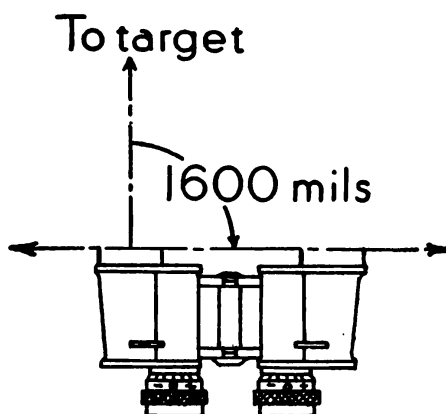


FIGURE 21.—Measuring a horizontal angle with the field glass.

lar to the line of vision) and pick out a point on the ground to mark the 1,600-mil line. A convenient scale for large measurements is the width of the field of view of the glass. This varies from 80 to 150 mils and should be noted for each instrument.

d. Focusing.—(1) A telescope is focused when the image formed by the objective is seen clearly through the eyepiece. The images of objects at different distances are formed at different distances behind the objective. In order that the image formed by the objective may be seen clearly, the eyepiece must be at a definite distance from the image. This distance varies with the peculiarities of the individual eye.

(2) Focusing is accomplished by moving the eyepiece until the object viewed is seen with maximum distinctness. Strictly speaking, a change of focus is necessary whenever the distance of the object viewed changes. Practically, however, with modern field glasses, when the instrument is focused for an object at average

distance, objects at all except very short distances can be seen at substantially their maximum distinctness.

(3) All modern military field glasses are constructed for separate focusing; that is, each eyepiece is focused independently of the other. The eyepiece is focused by screwing it in or out. There is a graduation in diopters (a unit expressing the refractive power of a lens), which permits the individual to determine his eyepiece setting for each eye, thus eliminating the need for focusing the field glass every time it is used.

(4) In focusing an eyepiece, the field glass is held in the normal position for binocular vision, with both eyes open. The hand is placed over the objective of the side other than that being focused. The eyepiece is then turned until maximum distinctness is obtained and the resulting eyepiece setting noted. The operation is repeated several times, about half of the trials being by turning the eyepiece in one direction, and half by turning it in the other direction. The mean of the several eyepiece settings thus obtained is accepted.

e. Interpupillary adjustment.—(1) All modern field glasses are constructed in two halves, each carrying a telescope. The halves rotate about a central axis parallel to the axes of the telescopes. This arrangement permits the distance between the eyepieces to be adjusted accurately to the interpupillary distance. A lack of adjustment in this respect prevents some of the light from both exit pupils from entering the pupils of the eyes, thus impairing illumination of the object viewed. After adjustment, rotation is prevented by means of a clamp.

(2) There is a scale near the central axis, graduated in millimeters of interpupillary distance. If the individual knows his interpupillary distance, the setting in this respect can be made by means of the scale.

(3) Accurate adjustment for interpupillary distance is made by moving the telescopes until the fields of view coincide accurately and appear as one perfect circle. If the telescopes are too far apart the field of view appears as an oval.

f. Care.—(1) Careless handling and hard knocks seriously affect the field glass. If thrown or dropped on a hard surface, even when cased, the parallelism of the lines of sight may be destroyed by even a slight bending of the frame; rough usage also may scratch or break the lenses, or fracture the dustproof sealing, thus permitting gradual internal fouling and mistiness of vision. Care begins with the case and straps, which should receive the attention due good leather. If a compass is built into the case, it is kept clamped when not in

use. The user determines and memorizes not only the interpupillary setting for his eyes, but that setting at which the glass will slip easily in and out of the case. When placing the field glass in its case the straps on the glass proper are rolled neatly about the frame. If dustproof covers are provided for the oculars, they are fitted before the glass is put into the case. An occasional examination is made to insure that the shoulder-strap keepers on the case are stitched securely.

(2) The frame of the glass is wiped at intervals with a clean rag to remove dust and grime. The lenses are wiped frequently with a clean chamois, dry linen cloth, or with optical cloth or paper, and no other substance is used for this purpose. It is advisable to keep some proper lens-wiping material in the case at all times for use when observation is necessary in dusty, misty, or rainy weather.

(3) For internal cleaning or repair, glasses of commercial manufacture are sent to the manufacturer; issue glasses are turned to the Ordnance Department.

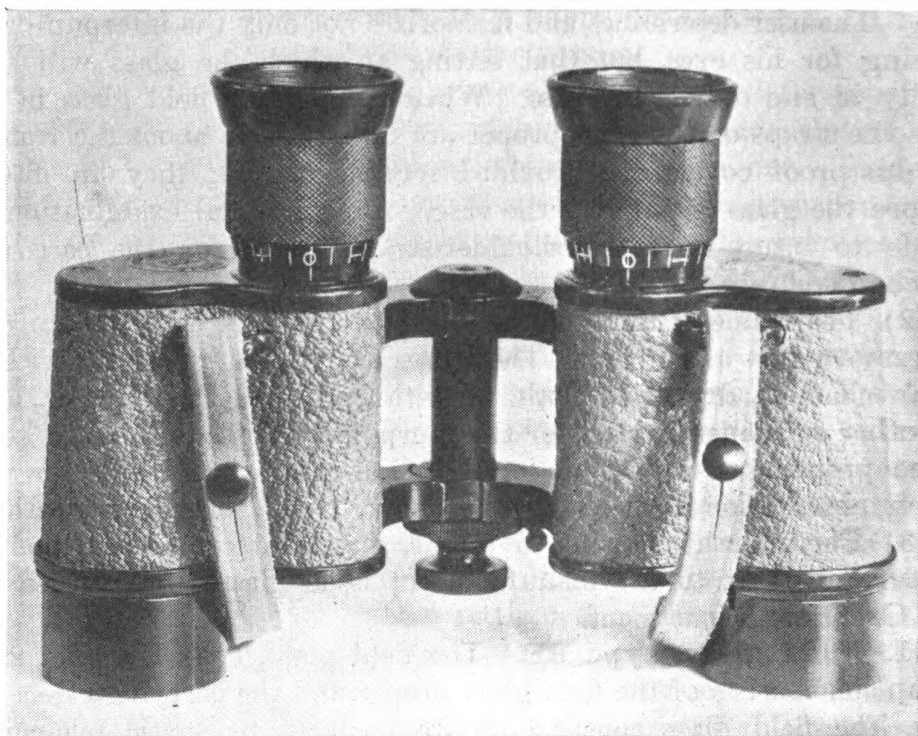
41. Field glass, type EE.—The field glass, type EE (fig. 22), complete, consists of the field glass proper and the carrying case.

a. The field glass consists of two compact prismatic telescopes pivoted about a common hinge which permits adjustment for interpupillary distance. A scale graduated every 2 millimeters, from 56 to 74, permits the observer rapidly to set the telescopes to suit his eye distance when the spacing of his eyes is known. The eyepieces can be focused independently for each eye, by screwing them in or out. Each is provided with a diopter scale for rapid setting, when the observer knows the corrections for his eyes. The zero graduations are the settings for normal eyes.

b. The left telescope of the issue field glass is fitted with a glass reticle upon which are etched scales as follows:

(1) *Old type field glass* (fig. 23).—A vertical mil scale, graduated at 3-mil intervals; a horizontal mil scale; and a stadia scale, corresponding to the inverted sight-leaf graduations on the service rifle. The last-mentioned scale is used with the rifle in indirect firing to obviate the difficulty of aiming at long ranges and at invisible field targets. It is not used in the artillery.

(2) *New type field glass* (fig. 24).—A horizontal mil scale; a vertical mil scale above the zero of the horizontal mil scale, with two graduations at 5-mil intervals; and a vertical scale at the left of the field of view, graduated at 5-mil intervals.



① Field glass.



② Carrying case.

FIGURE 22.—The field glass, type EE, with carrying case.

c. The optical characteristics are as follows:

Power.....	6
Field of view.....	8°
Diameter of exit pupil.....	.19 inch
Aperture of objective.....	1.19 inches
Effective focal length of objective.....	5.0 inches

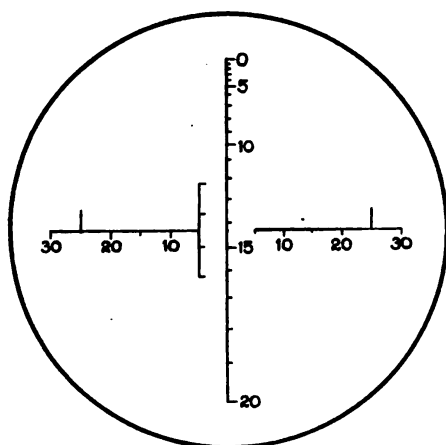


FIGURE 23.—Reticle graduations of the issue field glass, old type.

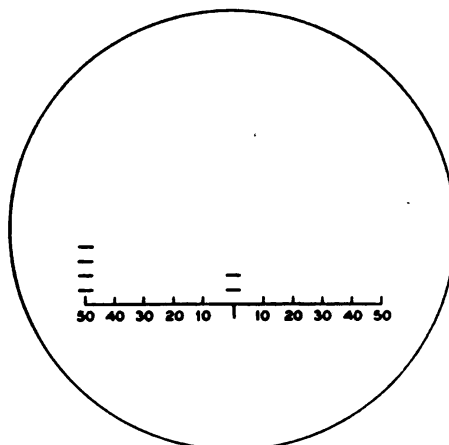


FIGURE 24.—Reticle graduations of the issue field glass, new type (artillery mil scale).

SECTION VI

PRISMATIC COMPASS, M1918

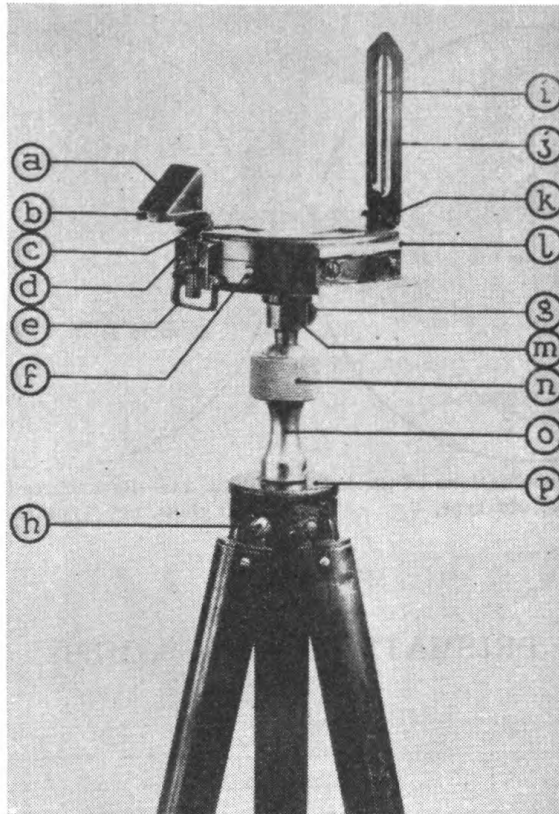
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42. General.—*a.* The prismatic compass is for use in measuring azimuth angles in reference to magnetic north, for which purpose it employs a magnetic needle. It also is equipped with a clinometer, by means of which vertical angles in mils (angles of site) may be measured.

b. The prismatic compass, M1918, complete, consists of a compass, a tripod, and carrying cases.

43. Compass (fig. 25).—*a.* Housed in the circular-shaped case are a compass dial and a sector-shaped clinometer dial.

b. The compass dial consists of a thin disk tinted green, carrying a magnetic needle and a jewel bearing, and revolving on a pivot secured to the lower portion of the case. The dial is graduated into



- a. Prism holder.
- b. Rear sight.
- c. Rear-sight slide.
- d. Rear-sight stop.
- e. Rear-sight strap.
- f. Spring stud.
- g. Head-bushing screw.
- h. Clamping screw.

- i. Front-sight vane.
- j. Front sight.
- k. Compass lift bar.
- l. Case support.
- m. Head bushing.
- n. Head ring.
- o. Head body.
- p. Head base.

FIGURE 25.—Prismatic compass, M1918.

640 equal spaces, each representing an angle of 10 mils, and numbered every ten spaces, or 100 mils, from 0 to 64. Two spring studs, one protruding through the case near the prism and the other through the front-sight bracket, are mounted on a spring. When either is pressed, it bears against the edge of the compass dial and acts as a brake for damping the motion of the dial. When released the dial rotates freely.

FIRE-CONTROL INSTRUMENT

c. The clinometer dial is mounted above the compass dial on a pivot inserted in a frame and attached to the top portion of the case. A section of the dial is cut away in order that the compass dial can be viewed. The dial contains two rows of graduations, each row graduated into 10-mil divisions. The inner row is numbered every 100 mils from 51 to 64 and continued from 1 to 19, with the 3 graduation especially indicated by an arrow. It is for use as a clinometer or level scale for measuring slopes, and readings are made opposite an index on the glass window. The outer row is numbered every 50 mils from 51 to 64, and continued from 1 to 19, with the 3 graduation especially indicated by an arrow. It is for use as an angle-of-site scale and is read through the rear and front sights when the clinometer dial is released. The figures are reversed in order that they may appear erect when viewed through the magnifying prism. The dial is weighted in such a manner that when the surfaces of the case support are in a horizontal plane the 3 graduation on the inner scale coincides with the index line on the glass window and the 3 graduation on the outer scale agrees with the horizontal line of sight passing through the front and rear sights. The clinometer brake button, when pulled out, releases the dial; when pushed in gradually it acts as a brake for damping; when pushed in farther, it clamps the dial.

d. The front sight, when turned down so as to lie flat on the compass case, engages the compass lift bar, which causes the compass dial to be lifted off its pivot and clamped; it remains clamped until the front sight is rotated to the vertical position.

e. The rear sight is mounted on a slide for raising or lowering in order that the magnifying prism may focus on the scale desired. The rear-sight strap, when rotated vertically, engages the rear-sight stop and retains the rear sight in the raised position.

44. Tripod (figs. 25 and 26).—The tripod is constructed entirely of nonmagnetic metal. Each leg consists of six sections of tubing and is so assembled as to permit the sections to telescope. The tubes are pivoted to the base, upon which is mounted the ball-and-socket mechanism for attaching and leveling the instrument. Pointed shoes are attached to the lower tubes for embedding the legs in the ground. The clamping screw (h, fig. 25) can be tightened to secure rigidity between the head base and legs.

45. Carrying cases.—The compass carrying case is approximately semicircular in form. On the front and back are small straps sewed to the case so that it may be affixed either to a belt or a shoulder strap. A case for the tripod is also provided.

46. To set up instrument.—*a.* Extend the tripod legs, spread them to the desired height, and embed them firmly in the ground. Grasp the head bushing with one hand and screw the instrument securely onto the threaded portion. Rotate the front and rear sights until vertical and raise the rear sight until the graduations desired are in focus when viewed through the magnifying prism;

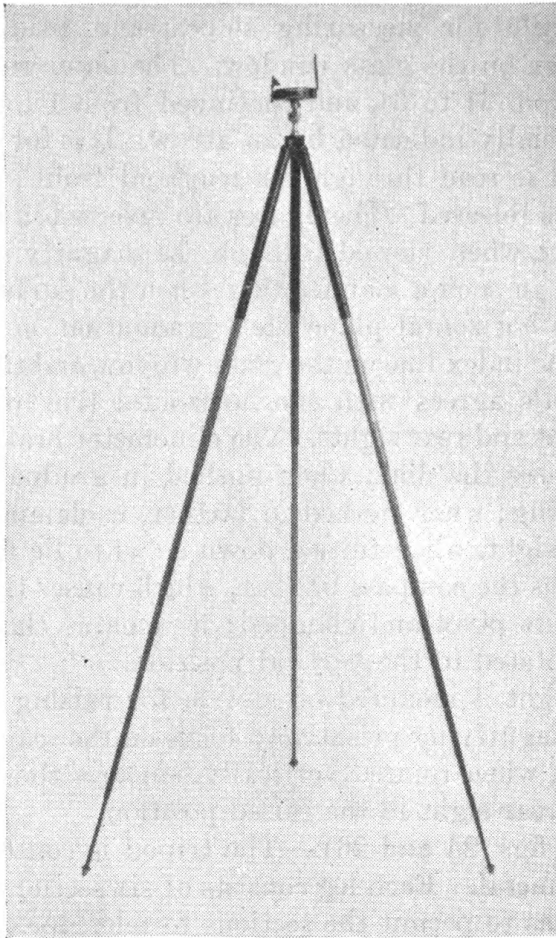


FIGURE 26.—Prismatic compass and tripod.

then level by means of the ball-and-socket joint until the compass dial rotates freely.

b. Satisfactory accuracy may be obtained with the prismatic compass without the use of the tripod, the instrument being held in the hands of the user or placed on a plane table or other flat surface. Care must be taken to remove all magnetic substances from the vicinity of the instrument while it is in use. The most common method of using the instrument is by holding it in the hands.

47. To measure azimuth (fig. 27).—Loosen the head-bushing screw and rotate the instrument until the object observed is in line with the niche in the rear sight and the vane in the front sight. The azimuth reading now indicated on the dial is in reference to compass north and is the clockwise angle from compass north to the object sighted.

48. To measure an angle of site.—Rotate the instrument downward until the head bushing is in the semicircular groove in the head ring. Pull out the clinometer brake button and release the head-bushing screw. Then elevate or depress the instrument until

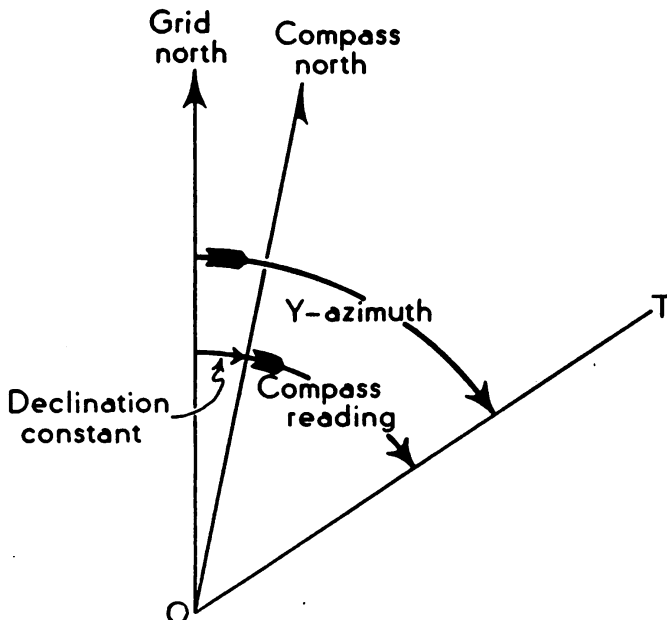


FIGURE 27.—Measuring an azimuth with the prismatic compass.

the line of sight intersects the object and note the angle-of-site reading on the clinometer dial (white dial).

49. Declination.—The compass is declinated in the same manner as is the aiming circle, M1918 (French). When the declination constant is added to a compass reading, the sum (less 6,400, if necessary) is the *Y*-azimuth of the direction.

50. Care.—When the instrument is moved from one position to another, the front sight is turned down to clamp the compass dial, and the clinometer brake button pushed in to clamp the clinometer dial, to prevent injury to the delicate pivots and bearings. The dials always are clamped, the front sight turned down, and the clinometer dial stopped so that the compass dial is visible, before placing the instrument in the carrying case. Care is taken not to dent the tripod legs. If dented they will not telescope properly.

SECTION VII

RANGE FINDER, M1916

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51. General.—*a.* The range finder is an instrument for use primarily in measuring distances. It may be used to measure horizontal and vertical (site) angles, but is not convenient for this purpose.

b. The 1-meter-base range finder, M1916 (fig. 28), complete, consists of the range finder proper, the mount, the tripod, the adjusting lath, and the leather carrying cases.

52. Range finder (fig. 29.)—*a.* The range finder is of the horizontal-base, inverted-coincidence type, which determines distance by a method of triangulation, on the basis of a base line 1 meter in length, corresponding to the spacing of the objective windows. The range scale is graduated in yards from 400 to 20,000.

b. The optical system (fig. 30) consists practically of two periscopes laid horizontally, so that their objective prisms are spaced 1 meter apart, but having one common eyepiece.

(1) Before the two images enter the eye lens, they pass through the ocular prism, which is so arranged as to divide the field as shown in figure 31.

(2) The object, when viewed through the eyepiece, appears as two objects, one above the other, with the upper inverted as shown in figure 31①; the images appearing to be separated by a line, beyond which they do not pass. This line is known as the halving line. In figure 31② the images are shown when coincidence is secured and when halving adjustment is correct. In figure 31③ the images are shown when the halving line is out of adjustment.

(3) In order to measure ranges accurately, the halving line must be in adjustment with coincidence secured, as shown in figure 31 ②.

(4) The eyepiece can be focused by rotation, and a diopter scale is provided for rapid setting, once the observer has determined the

correction for his eye. The zero mark indicates the setting for the normal eye.

(5) A ray-filter holder containing one smoked and one amber glass is pivoted within the eyepiece adapter and controlled by the ray-filter lever near the eyepiece.

(6) The smoked glass is provided for observing into the direct rays of a searchlight or of the sun, and the amber glass is used to moderate exceptionally bright daylight or the reflection of the sun over water.

(7) The open sight, mounted on the top of the tube to the right of

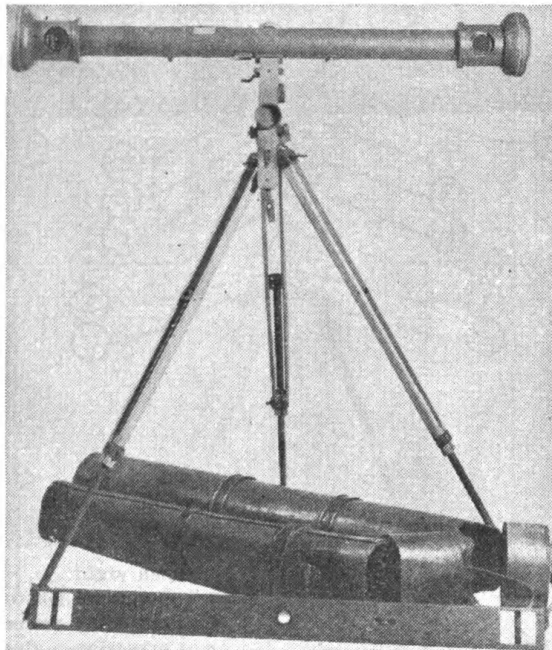


FIGURE 28.—Range finder, M1916, with carrying cases and adjusting lath.

the eyepiece, permits rapid training of the instrument on the object.

(8) The adapter, attached to the tube below the eyepiece, is provided as a means for attaching the range finder to the support on the upper portion of the mount.

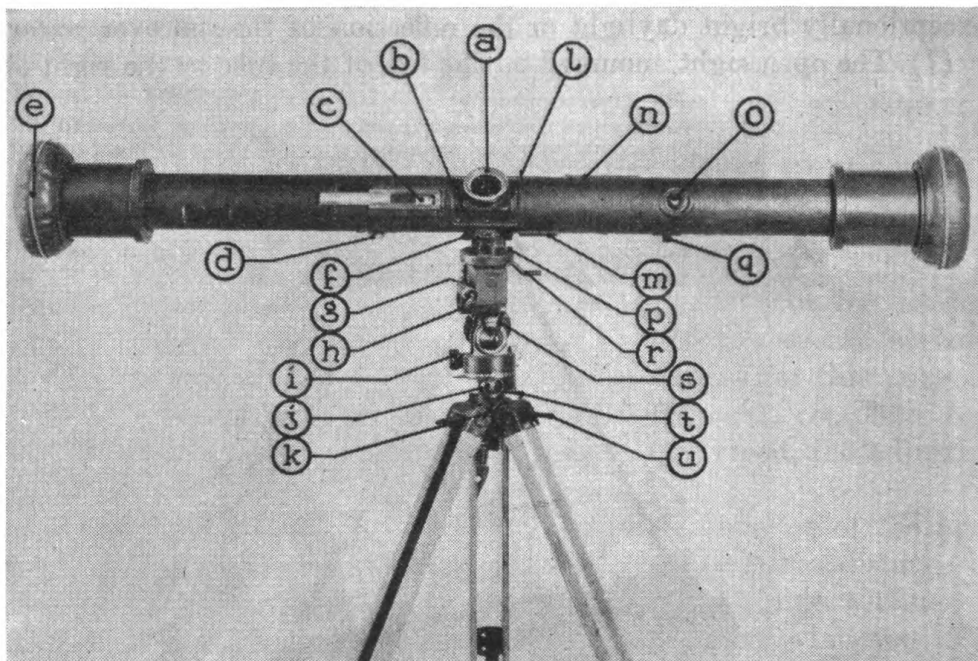
c. The optical characteristics of the instrument are as follows:

Power.....	15
Field of view.....	3°10'
Diameter of exit pupil.....	.1 inch
Aperture of objective.....	1.5 inches
Effective focal length of objective.....	8.55 inches

53. Mount (fig. 29).—*a.* The mount consists of an azimuth mechanism above which is hinged the elevation mechanism by which means the line of sight can be rotated approximately 18° above and below

the horizontal. The angle-of-site mechanism is attached to the left side of the elevation mechanism. When the support clamp lever is released, the range finder can be rotated horizontally approximately 10° , independently of the other motions.

b. The azimuth circle is graduated into 64 equal spaces, each representing 100 mils of angle, and numbered from 0 to 64. The azimuth



- | | |
|--|-------------------------------------|
| a. Eye shield. | l. Open sight. |
| b. Ray-filter lever. | m. Halving adjuster. |
| c. Range scale. | n. Measuring roller. |
| d. Gimbal joint cover. | o. Correction-wedge window. |
| e. Buffer. | p. Support. |
| f. Adapter. | q. Correction-wedge control. |
| g. Elevation knob. | r. Support clamp lever. |
| h. Angle-of-site micrometer. | s. Hinge clamp screw handle. |
| i. Azimuth micrometer. | t. Vertical-spindle clamping lever. |
| j. Azimuth adjusting worm knob. | u. Locking clamp arm. |
| k. Vertical-spindle bushing locking screw, with chain. | |

FIGURE 29.—Range finder, M1916.

micrometer is graduated into 100 equal spaces, each representing 1 mil of angle, and numbered from 0 to 100. One turn of the micrometer advances the index one space or 100 mils, which corresponds to the number of graduations on the micrometer.

c. The throw-out lever, when rotated and held, disengages the azimuth worm from the teeth on the worm wheel, permitting free rotation of the upper portion of the mount carrying the range finder and

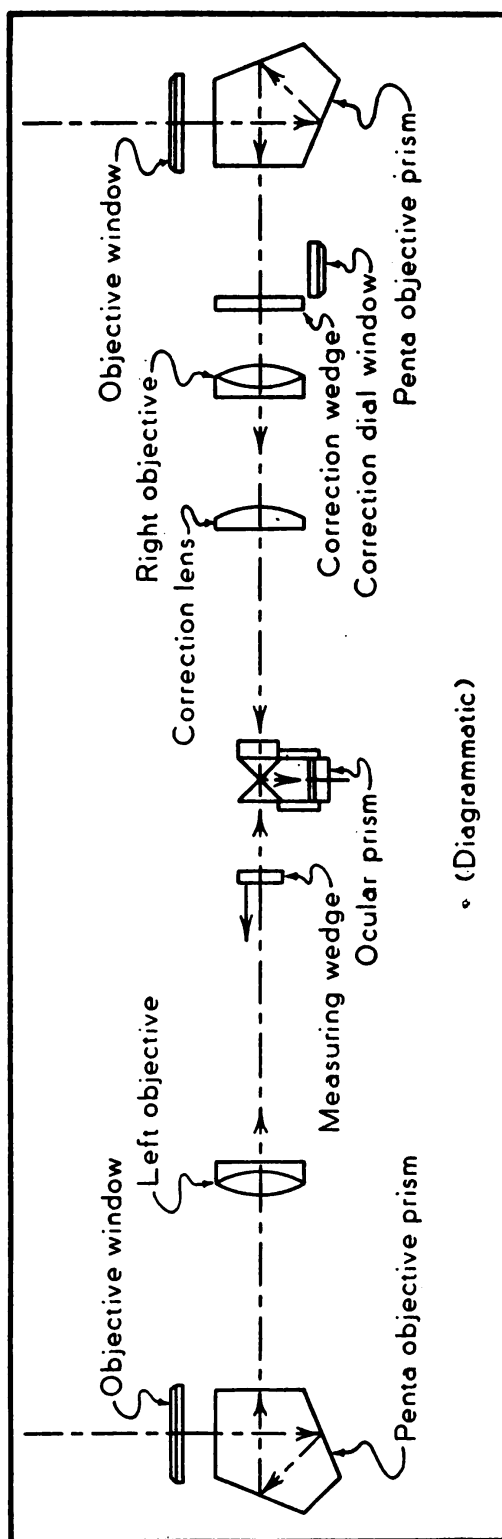


FIGURE 30.—Optical system of the range finder, M1916.

azimuth index. With the azimuth worm engaged and the vertical-spindle clamping lever loosened, free rotation of the entire azimuth mount and range finder is obtained. Rotation of the azimuth adjusting-worm knob causes movement of the azimuth circle and the upper

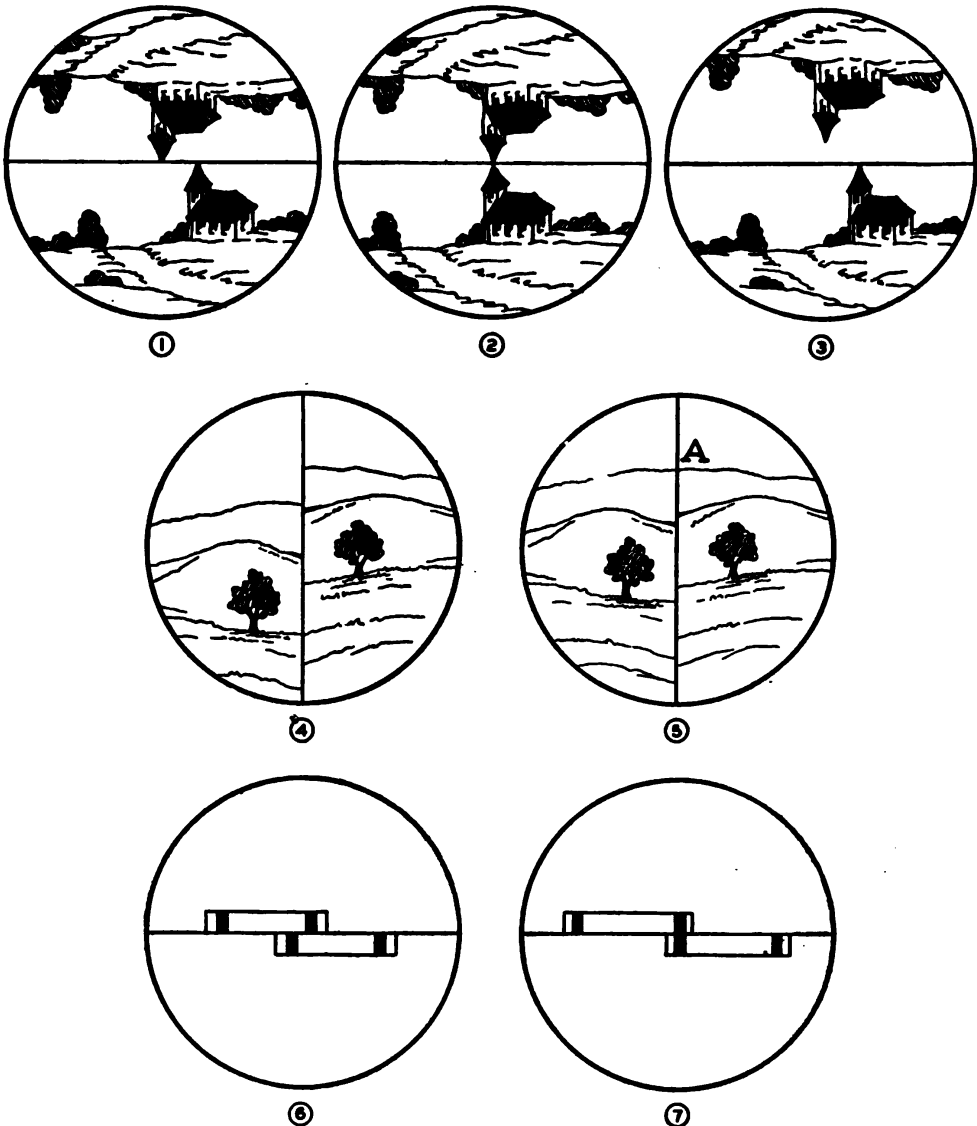


FIGURE 31.—Adjustment for measuring range with the range finder, M1916.

portion of the azimuth mount, by which means fine adjustment is obtained for orienting.

d. The angle-of-site scale is graduated into six equal spaces, each representing 100 mils of angle, and numbered from 0 to 6, the 3 graduation indicating the level position. The angle-of-site microm-

eter is graduated into 100 equal spaces, each representing 1 mil and numbered from 0 to 100. One complete turn of the micrometer advances the index one space or 100 mils, which corresponds to the number of graduations on the micrometer.

e. Rotating the hinge clamp screw lever permits the upper portion of the mount to move laterally, by which means the range finder can be placed in a vertical position.

f. The mount is kept attached to the tripod at all times, but can be removed easily by loosening the vertical-spindle clamping lever and the vertical-spindle bushing-locking screw.

54. Tripod (fig. 28).—*a. General.*—The tripod, type U, is issued with this instrument. In describing the tripod, no reference is made to the azimuth mount, as it is considered to be a component of the instrument and not of the tripod.

b. Tripod legs.—The legs consist of two sections.

(1) The upper sections are pivoted to the tripod head and may be clamped by means of the locking-clamp arms to prevent the legs from spreading.

(2) The lower sections consist of steel tubes which slide freely through the lower portions of the upper sections and may be clamped by means of the wing nuts. Pointed shoes, driven in the lower ends, permit embedding the legs in the ground.

c. Tripod head.—The tripod head is similar to that of the type G (par. 30) except for the shape of the hole in the split steel bushing to receive the mount. The bushing may be contracted by means of the vertical-spindle clamping lever for gripping the ball-and-socket joint of the azimuth mount.

55. Adjusting lath (fig. 28).—The adjusting lath consists of a metal strip upon which two vertical lines are painted, the distance between which is the same as the distance between the optical axes passing through the windows of the range finder. This makes each lath applicable only to the range finder with which it is issued. The lath is serially numbered the same as the range finder, and always should be kept with it; adjustments should be made with no other lath. The sight, placed at the center, is for observing the center of the range finder when adjusting.

56. Carrying cases.—*a.* The range finder proper is carried in a cylindrical leather case, reinforced with two steel hoops. The case has an opening at one end, closed by a cylindrical leather cap.

b. The tripod and adjusting lath are carried in a case similar to that of the instrument proper, but with one flat side where a recess is provided for carrying the lath. The head-closing cap of this case has

wood reinforced compartments for carrying the lath sighting tube, the adjusting key, a small chamois, and a camel's-hair brush.

57. To set up instrument.—Extend the tripod legs to the desired height, embed them firmly in the ground, and place the range finder on the mount.

58. To measure a distance.—*a.* Rotate the throw-out lever and hold in position; then rotate the telescope until the line which appears in the lower half of the eyepiece is approximately on the object. The images when not in coincidence will appear as in figure 31 ①. To obtain coincidence, rotate the measuring roller until the images appear as in figure 31 ②; the range is then indicated on the range scale. The mean of several readings is taken when time permits.

b. To determine the range to an object with horizontal outline, such as roads, trenches, and crests, place the range finder in the vertical position. Train on the object as described previously, using the halving line as the vertical line. The images will appear as in figure 31 ④ when not in coincidence. The object whose range is desired should be brought into coincidence as in A, figure 31 ⑤.

59. To measure a horizontal angle.—While not convenient for the purpose, horizontal angles may be measured with the range finder in a manner similar to that used with the battery commander's telescope and the aiming circle.

60. To measure an angle of site.—Rotate the elevation knob until a portion of the object whose angle of site is desired appears on the halving line; then rotate the angle-of-site micrometer until the bubble is midway between the graduations on the level vial, and note the reading on the scale and micrometer.

61. Adjustment.—*a.* To adjust the halving line (fig. 31 ③), rotate the halving adjuster until the images appear as in figure 31 ①.

b. There are two methods of making adjustment for range; the infinity method and the known-range method.

(1) *Infinity method.*—To adjust by the infinity method, place the adjusting lath in a horizontal position about 200 yards or more from the instrument and set the range scale to indicate infinity. If the images of the lath appear as in figure 31 ⑥, the instrument is out of adjustment and it is necessary to adjust the correction wedge by rotating the correction-wedge control until the images appear as in figure 31 ⑦. In case the adjusting lath is not avail-

able, the moon may be used and the same procedure followed as described above. The sun is never used as a target for adjusting a range finder because the rays when in focus at the halving line may cause the balsam, used in cementing the ocular prism, to melt, thus injuring the optical system.

(2) *Known-range method.*—To adjust by the known-range method, select some object at a medium distance, the range of which is known, and set the range scale to indicate the range; if the images appear as in figure 31 ①, the instrument is out of adjustment, and it is necessary to adjust the correction wedge by rotating the correction-wedge control until the images appear as in figure 31 ②. Repeat this operation several times, note the reading on the correction scale through the correction-wedge window, and set the scale at the average of these readings.

(3) If the range finder is used over a period of several hours, it should be readjusted at frequent intervals. The change in the angle of the sun's rays affects vision to such an extent that readings obtained with the instrument will vary appreciably from hour to hour.

c. To adjust the azimuth micrometer, rotate the azimuth circle until the index coincides with a graduation; then loosen the locking screw which secures the micrometer to the worm shaft and rotate the micrometer until the zero coincides with the index; then tighten the screw.

d. To adjust the angle-of-site micrometer, set the index to coincide accurately with the 3 graduation on the scale; then loosen the retaining screw and rotate the micrometer until the zero coincides with the index; then tighten the screw.

62. Care.—a. All unnecessary turning of screws, not incident to use, is forbidden. The gimbal joint cover to the left of the eyepiece on the upper side of the tube is not removed in the field, as the slightest disturbance of the parts enclosed therein renders the instrument inaccurate.

b. Before mounting the instrument on the tripod, the covers on the ends are rotated to expose the windows.

c. When the instrument is mounted, its ends must not be touched or bumped, as the parts at the center will be subjected to undue strain, thus tending to shear off the small screws securing the adapter to the tube.

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NONOPTICAL INSTRUMENTS

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63. Accessories.—For drawing rays on maps or charts, a hard pencil, 6H or harder, is used. For accentuating locations, and labeling data, a 4H or softer pencil is used. For accurate work in drawing lines, a tapering point is best; it is kept sharp by rubbing on fine sandpaper. A soft rubber eraser or art gum is used to erase lines when necessary. Thumbtacks must be of brass or nonmagnetic metal when the declinator is used on a plane table. A fine needle is useful to prick points in the chart or map to prevent erasure of points.

64. Alidade (fig. 32).—The alidade is a device to determine the direction of a line by sighting along it. It is a brass rule, having in its center a spirit level, and at each end a hinged leaf. The rear leaf has a narrow slit, with three peepholes. The front leaf has a wide slit along the center of which is stretched a fine thread. A slide on the front leaf allows the measurement of site. In front of the rear leaf is a flatheaded screw which extends through the alidade. This screw raises or lowers the rear end of the alidade when it is on the board, and allows it to be leveled. When the bubble is centered, *plus* site may be read using the lower peephole in the rear leaf, and the right-hand graduations of the front leaf; *minus* site, by using the upper peephole, and the left-hand graduations of the front leaf.

65. Plotting scales.—*a. The triangular plotting scale* (fig. 33).—This scale is of boxwood with a triangular cross section. Engraved on it are several scales for use on the various standard maps and charts. It may also be used as an alidade. For this purpose the upper edge is used in sighting on an object. A line drawn along one of the lower edges records the direction of the line of sighting.

b. The flat plotting scale (fig. 34).—This is a flat boxwood rule having graduations in yards and in meters to a scale of 1:20,000. The least reading is 10 yards.

66. Protractor (fig. 35).—The protractor most useful for artillery work is a 16-inch semicircle of transparent material. It is used to measure azimuths, firing angles, and deflections between datum lines on a map, firing chart, or air photo.

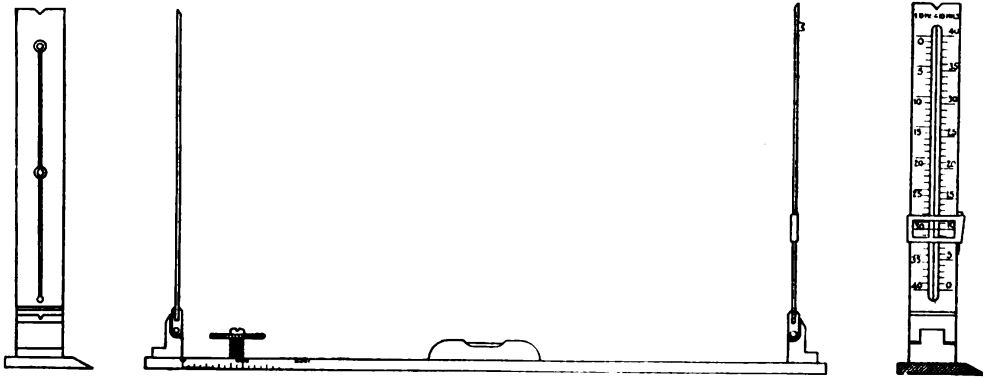


FIGURE 32.—Alidade.

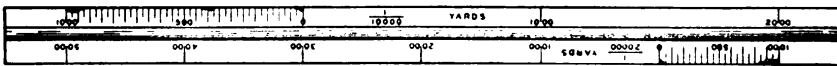


FIGURE 33.—Triangular plotting scale.

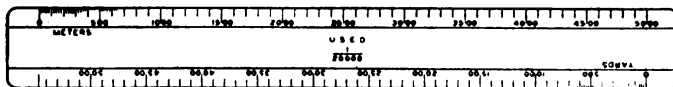


FIGURE 34.—Flat plotting scale.

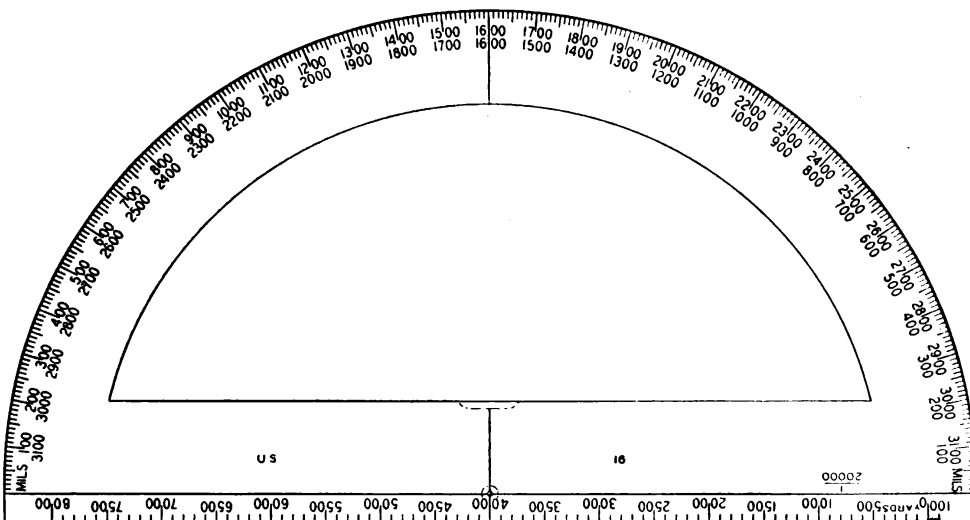


FIGURE 35.—Protractor.

67. Range-deflection fan (fig. 36).—The fan is a protractor made of transparent material. It has rays from the center drawn at 20-mil intervals and concentric arcs differing in radius by 100 yards (scale 1:20,000). It is used primarily in rapid plotting. If extreme accuracy is not essential, its use eliminates the drawing of certain unnecessary lines and permits range and angular measurements to be made in a single operation.

68. Straightedge (fig. 37).—The straightedge is a metal rule, 24 or 30 inches long, having graduations in yards to a scale of 1:20,000 engraved along one edge.

69. Recorder, time-interval, single-hand (fig. 38).—*a. Description.*—This time-interval recorder is a watch-like tally with a single hand. The main dial is graduated to read in seconds and fifths of seconds. Every 5-second mark is numbered and a small subdial records the minutes from 0 to 30. One complete revolution of the second hand moves the minute hand one space. It is stem-wound and the hands are started, stopped, and returned by pressing the stem. A rubber shock absorber and a leather chain are supplied with each recorder.

b. Use.—The time-interval recorder is used when precise measurement of elapsed time is desired.

c. Care.—The time-interval recorder is delicately constructed. It should not be dropped or subjected to unnecessary shocks. To protect the crystal, it is carried with the face placed next to the body.

70. Recorder, time-interval, double-hand (fig. 39).—This time-interval recorder is similar to that described in paragraph 69, except that it has two hands, one operated by pressing the stem and the other by a button which is set in the edge of the case. They are mutually independent. By this means "time out" during any measurement may be accurately obtained. In addition, an auxiliary dial, of the same type as the second hand of an ordinary timepiece, is fixed in the lower half of the face of the instrument. A stop watch may be issued in lieu of the time-interval recorder.

71. Tape, steel, 100-foot (fig. 40).—*a. Description.*—The 100-foot tape consists of a graduated steel strip inclosed in a circular metal case. It is graduated in feet and inches. A small knob mounted on a hinge near the center of the case is provided to rewind the tape after using.

b. Use.—The tape is held level while measurements are being made. On steep slopes it may be necessary to make a number of short measurements to avoid the error introduced by inclining the tape,

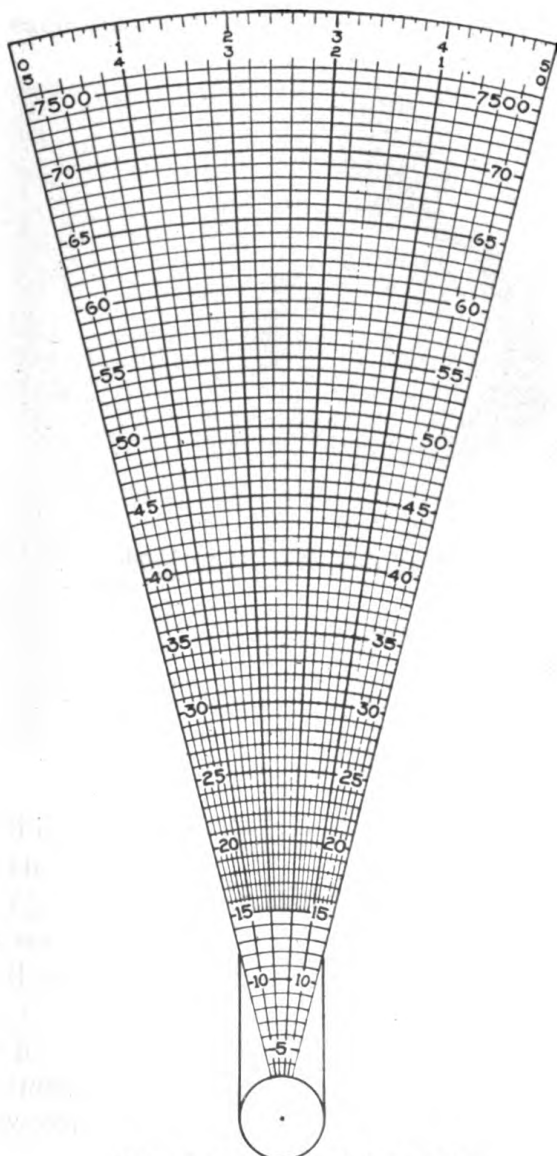


FIGURE 36.—Range-deflection fan.

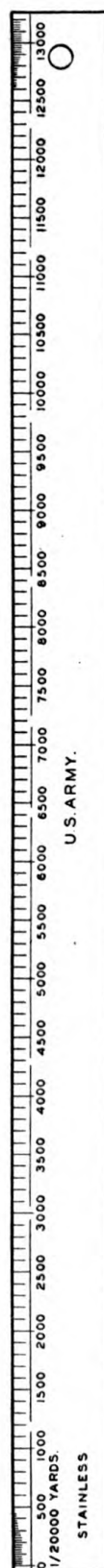


FIGURE 37.—Straightedge.

or to measure the slant distance and the angle of slope and from these compute the horizontal distance.

c. Care.—Care is taken not to kink or subject the tape to sharp bends, as it is constructed of tempered steel and will break. If used in wet weather it is dried before rewinding, and wiped with an oily rag to help prevent the formation of rust.

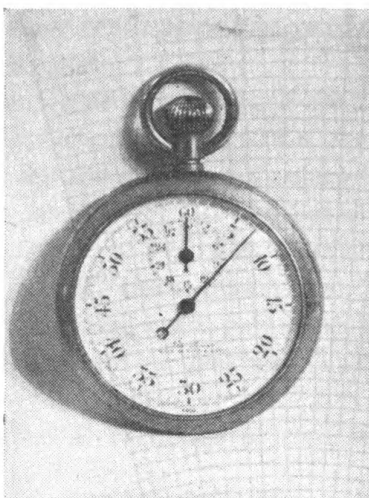


FIGURE 38.—Time-interval recorder, single-hand.

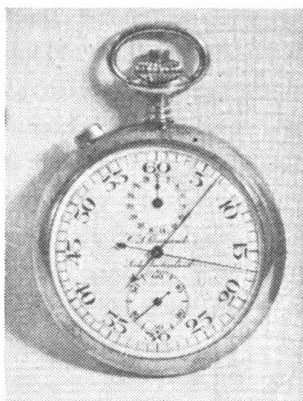


FIGURE 39.—Time-interval recorder, double-hand.

72. Thermometer.—*a. Description.*—The thermometer is graduated in degrees, Fahrenheit, from 23° below to 130° above zero, and numbered every 10° .

b. Use.—The thermometer is used to determine the temperature of the powder and of the air.

c. Care.—The thermometer is handled carefully to prevent the breaking of the delicate glass tube, or separation of the measuring column.

73. Plane table.—The plane table is most useful for locating points and measuring data. Its disadvantages are that it is conspicuous, bulky to carry, and the work cannot be exposed to wet weather.

a. Description.—The plane table consists of a drawing board, a tripod, and a declinator.

(1) *Drawing board* (fig. 41).—The drawing board has a small hole at each corner for attaching the declinator; on the under side

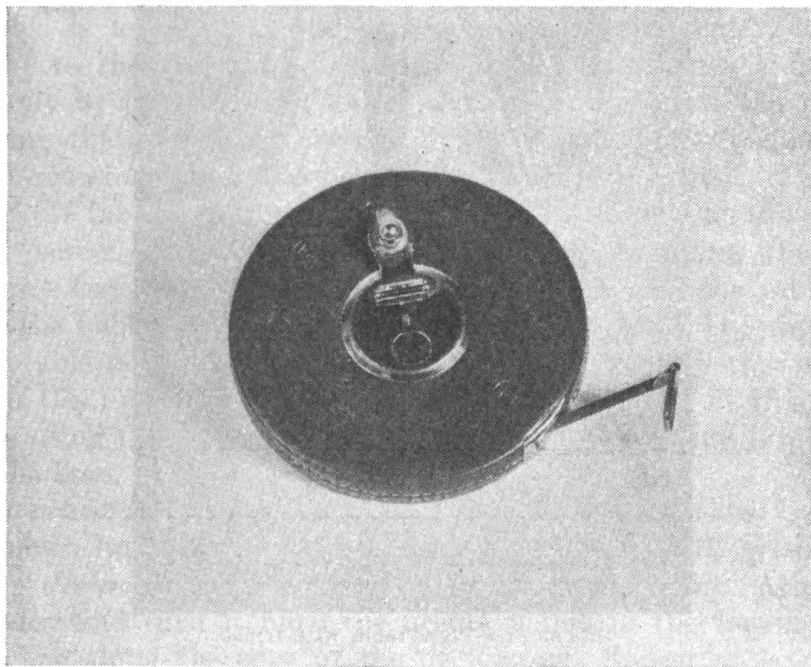


FIGURE 40.—Steel tape, 100-foot.

of the drawing board is a screw socket for securing the drawing table to the tripod.

(2) *Tripod* (fig. 41).—The tripod head has a screw which fits into the socket on the under side of the drawing board. By means of a ball-and-socket joint the drawing board may be leveled independently of the position of the tripod legs. When the drawing board is leveled, it may be rotated in the horizontal plane by loosening the lower wing nut. Each tripod leg may be adjusted for height by wing nuts on the lower end of the upper leg. Each leg can be locked to the head by a wing nut.

(3) *Declinator* (fig. 42).—The declinator, usually called the needle, is a magnetic needle mounted in a narrow metal box. It is secured to the drawing board by a screw fitting in one of the corner holes.

b. To set up plane table.—Set up the table approximately level, two legs being placed downhill if the board is on a slope. In general, it is sufficiently accurate to set the center of the table over the station

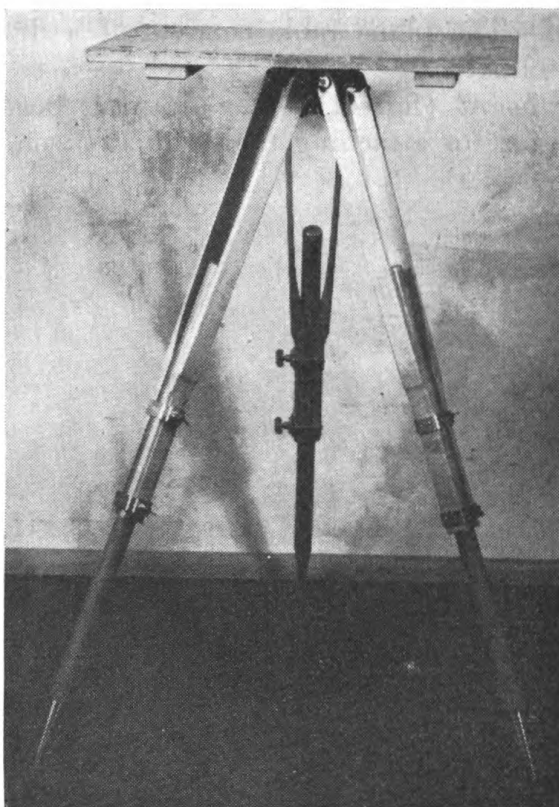


FIGURE 41.—Plane table, with tripod.

point, but when the plotted point is near the edge and the object sighted upon is not distant, the table is set up so that the plotted point is over the point on the ground.

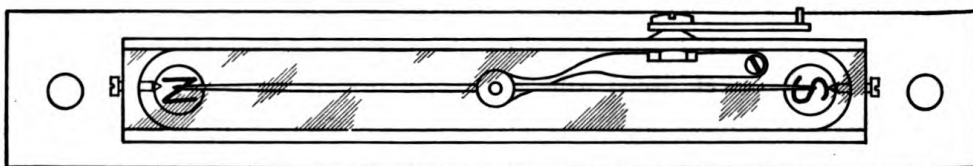


FIGURE 42.—Declinator.

c. To attach a grid or map.—The sheet is fastened to the table so that the grid lines are parallel to the edges of the table. The sheet should be larger than the table, with the surplus folded over the edge and fastened with brass thumb tacks. A strip of cardboard or heavy paper, placed along the edge of the sheet under the tacks,

will prevent tearing. The waterproof cover is used to protect the work when the table is not being used.

d. To level plane table.—The table is leveled with the alidade in two positions, at right angles to each other. Level the table by eye and partially tighten the upper wing nut. Turn the leveling screw in the base of the alidade until about one-half of it projects through the base. Place the alidade along the longer axis of the table and center the bubble by tapping an edge of the table. Reverse the alidade. If the bubble is in the center, the long axis of the table is leveled. If the bubble is not in the center, bring it halfway to the center by means of the leveling screw, and center it exactly by tapping an edge of the table. Continue the process, reversing the alidade and centering the bubble as above, until the bubble remains centered when the alidade is reversed. The long axis of the table now is level. The alidade is a level at this setting of the screw, and may be so used without changing the screw settings. Lay the alidade along the short axis of the table, and center the bubble by tapping the edge of the table. The short axis of the table now is level. Check the leveling along both axes, and tighten the upper wing nut so the table is secured in this plane. Before using the alidade for sighting, have the leveling screw flush with the base.

e. To orient plane table.—The plane table may be oriented by means of a known line, plotted on the table, and visible on the ground.

f. To declinate plane table.—Orient the plane table. Attach the declinator and turn it until the needle points to the index. Draw a fine line along the edge of the declinator. Repeat at least three times. The mean of the line is the declinated position and is marked. There should be no magnetic objects near the needle. A pocket knife, watch, keys, steel thumbtacks, or cap grommet will influence the needle materially. Steel helmet, pistol, and large steel objects should be removed 10 yards.

g. To draw a ray through a point.—With the alidade slightly to the right of the plotted point, sight on the object. Draw a light line a short distance along the edge of the alidade near each end and move the alidade parallel to this line until its edge is on the plotted point. Check by sighting the point, and repeat until there is no error. Draw a ray. Do not pivot the alidade around a needle stuck in the plotted point if the point is to be used a number of times, as this will make the point too large for accurate work.

h. Adjustment and care.—The plane table and tripod require no adjustment when reasonable care is given them. The clamps on the

tripod head are loosened when the table is not in use. Periodic examination of the board is made to insure that the plate for attachment to the tripod head has not become loosened where the screws enter the wood of the table.

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ADJUSTMENT AND CARE

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74. General.—Properly to take care of an instrument, the person charged with its use familiarizes himself with the methods of mounting, functioning, use, and adjustment of the instrument.

75. Minor repair and adjustment of instruments.—*a.* The only repairs permitted in the field by battery mechanics are the replacing of knobs, micrometers, or other parts that can be disassembled easily with the usual tools issued.

b. The only adjustments permitted in the field by the battery mechanics are stated in the description of each instrument.

c. Backlash in the worms of instruments equipped with throw-out levers can be removed by adjusting the screw plug which controls the plunger spring.

76. Care in handling.—*a.* Fire-control instruments contain delicate mechanisms and accurately arranged optical parts, and are handled gently to avoid all unnecessary shocks which would eventually render the instrument unserviceable.

b. When using instruments equipped with throw-out or eccentric levers for disengaging worms from their worm wheels when rapidly training on objects, care is taken to rotate the throw-out levers sufficiently to prevent the worm from scraping over the teeth on the worm wheel, which action eventually would damage the teeth, causing inaccurate readings.

c. Instruments provided with carrying cases, chests, and the like, are placed therein without undue force.

77. Disassembling.—*a.* Under no circumstances will the disas-

sembling of any instrument, or part thereof, be made except by a skilled mechanic familiar with fire-control instruments and authorized by the ordnance officer to make repairs.

b. All unnecessary turning of screws not incident to the use of instruments is forbidden.

c. Instruments which fail to function properly are returned to the authorized section of the Ordnance Department for repairs.

78. Oiling.—All interior moving parts of fire-control instruments are oiled or greased when assembled; such oiling or greasing being sufficient lubrication to last for a considerable length of time. Moving or exposed parts requiring oiling or greasing are lubricated sparingly with the lubricants furnished by the Ordnance Department for fire-control instruments, and none other. Care is taken that no oil or grease reaches the optical parts or other parts that do not require lubrication. Excess lubricants that seep from the mechanism are wiped off to prevent the collection of dust and grit.

79. Care of lenses and windows.—*a.* To obtain satisfactory vision, the surfaces of the lenses and windows are kept clean and dry.

b. To avoid scratching, clean soft linen, optical cloth, or paper, chamois, and camel's-hair brushes, free from grit, dust, and lint, are used for cleaning lenses.

c. Under no circumstances whatever will polishing liquids and pastes be used for polishing lenses and scales.

d. To remove oil or grease from lenses and windows, apply alcohol with a rag or camel's-hair brush and rub off gently with a clean rag or lens paper.

e. To remove dust, brush lightly with a camel's hair brush, and rap the brush against a hard body, knocking out the small particles of dust which cling to the hairs. Continue this operation until the dust is removed.

f. Do not wipe off lenses with the fingers.

g. Occasionally, moisture collects on the lenses of optical instruments, owing to condensation caused by the temperature of these parts being lower than that of the surrounding air. Placing the instrument in a moderately warm place usually removes such moisture. Care is taken to avoid subjecting the instruments to sudden or unusual degrees of heat, lest unequal expansion of parts cause inaccuracies of alinement.

80. Protection from weather.—Instruments are protected from wet weather as much as possible, and, when used during a rain, are wiped off with a cloth as soon as practicable after the rain

ceases. They are never returned to their cases wet; and are always stored in a warm, dry place.

81. **Tools, accessories, and cleaning material.**—The following is a list of authorized tools, accessories, and cleaning materials for the maintenance, adjustment, and preservation of the instruments:

Instrument	Tools and accessories	Cleaning material	Where carried
Range finder.....	1 adjusting key.....	{1 cleaning brush..... 1 chamois skin.....	}Instrument carrying case
Battery commander's telescope.	2 amber glass disks..	{1 chamois skin..... 1 camel's-hair brush.....	
Field glasses.....		{1 chamois skin..... 1 camel's-hair brush, small..	}Carrying case.

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[A. G. 062.11 (10-14-40).]

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